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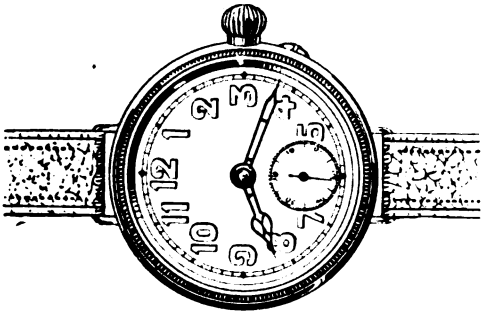

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FOREWORD.

THE change in the publication of this *Journal* from monthly to quarterly issue calls for some brief Introduction.

The proposal emanated, more than a year ago, from an officer who may be considered as fairly representative of those junior ranks, who, in the Great War, distinguished themselves, and brought honour on their Corps, by gallantry in action and by marked technical skill. The opinions of such officers are of the greatest weight, not only because they have learned by executive experience what they require, but because it is on them that the future of this branch of the Imperial Army will depend. The views, therefore, of all such were solicited, and the consensus of opinion was undoubtedly in the direction of something better than the existing form.

Progress in all forms of engineering and of military science is continual, and it is necessary for those responsible for policy continually to revise their methods of efficiency. Such a revision was made shortly after the South African War in the change which then (1905) took place in the form and scope of the *R.E. Journal.* That the changes which then took place were an improvement on the preceding issues, is admitted. The time has now come for a further advance.

Certain preparatory steps have, however, been taken, which it is hoped have already tended to improvement, and may be still further developed. One of these steps is the appointment of a small Advisory Committee, consisting of officers of high rank, responsible for actual administration and instruction, and of others who are elected by the Council of the Institution for personal qualifications. On this Advisory Committee devolves the duty of directing the Secretary of the Institution as to the scope and character of the articles to be published, and thus relieving him of a responsibility which it is thought he should not have to bear alone.

Another step is the granting of small pecuniary awards to the writers of selected articles, as a recognition of the trouble they have taken, and of the value of the information given.

In considering the policy of production of a quarterly journal, the members of the Council of the Institution endeavour to keep before them certain fundamental principles. Of these the most vital is that the value of military engineering depends absolutely on its correlation with military science, both in Operations and Administration. Unless, therefore, this science is thoroughly and intimately absorbed by the military engineer, not only will much of his energy be misdirected, but the confidence with which his assistance and opinions are accepted by other arms will be seriously impaired. Articles on purely military subjects which would be out of place in a civil engineering journal are therefore properly suitable for our consideration. On the

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other hand, among the lessons of the Great War, one of the most valuable is the importance of civil engineering, in its many branches, to an army in the field, not only in works on the Lines of Communications, but in the sphere of actual combat. It is unnecessary to labour this point; the sequel to it must be that, more than ever in the past, the military engineers of our Empire must keep in touch with their civil brethren, whose splendid conquests of natural difficulties go on without ceasing, and who, in their varied researches, and in their published periodicals are affording us continually the insight into new vistas of scientific and practical knowledge. The fact that many officers of the Royal Engineers cannot keep in touch with these various civil technical journals makes it imperative that the Institution should keep them informed of the most important developments in civil life.

While it is recognized that physical science must be at the basis of engineering, it is remembered also that practical experience of actual work is specially valuable. In the past the records (in the *R.E. Journal*) of experience gained, in peace or war, has been comparatively small. It is hoped that an improvement in this respect may be forthcoming. It is hoped that senior officers will encourage those serving under them to write papers on the results of actual experience, and it is to such papers that the Institution would desire most liberally to make pecuniary awards. Officers are sometimes reluctant to write about what they have done, lest it should be thought that they are glorifying themselves. Any idea of this sort may be at once dismissed. They are helping those that follow them, and who may have similar work to do.

As many as possible of the lectures given at the School of Military Engineering by experts will be published, so as to reach a larger audience than can be present at the time of actual delivery.

In geographical and survey work of all kinds, the record of the Royal Engineers in the past has been of the highest. It is believed that in the future it will continue to be in the van of progress in this respect. Papers on the subject will, it is hoped, appear in the pages of the *Journal* from time to time, and any communications in respect of observation and exploration will be very gladly welcomed.

It is hoped, too, that the lighter side of the varied life of the Corps will not be entirely overlooked. It has its importance, and the records of travel, adventure and sport are acceptable in a journal whose readers are in many cases none the worse soldiers and engineers because they ride straight or can manage a yacht in heavy weather.

Such is the programme. It is a big and ambitious one, but with the hearty co-operation which the Council have every reason to anticipate, it is one to which they look forward with confidence.

G. K. SCOTT MONCRIEFF, *Major-General,*
Vice-President, Institution of Royal Engineers.

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THE NECESSITY FOR ENGINEER INTELLIGENCE TO ENGINEER COMMANDERS IN WAR, AND HOW IT MAY BE OBTAINED.

Cooper's Hill Memorial Prize Essay, 1922, by PRÉVOIR (Capt. C. DE L. GAUSSEN, M.C., R.E.).

IN the history of almost every campaign incidents abound which illustrate the far-reaching effect that Engineer Intelligence, or the lack of it, brings to bear on the result of operations. A study of a few such incidents will assist us in framing a definition of the term, in its widest sense, and in appreciating the importance of good engineer intelligence to Engineer Commanders, and hence to all Commanders of formations.

Taking an example of a situation in which the value of engineer intelligence, as applied to river crossings, was appreciated, we cannot do better than to turn to the battle of Assaye. Wellesley, operating against the Maratha chiefs Holkar and Scindia in 1803, had pursued them from Ahmednagar and found their armies drawn up on the left (north) bank of the Kaitna; he was on the south bank, with no means of crossing the river. All the natives declared there were no fords or crossings in the neighbourhood. Wellesley, however, noticed four miles down the river that on both banks there were two villages opposite one another. At once he realized that here, if anywhere, there must be a crossing: his knowledge of Engineer Intelligence and Reconnaissance served him well and enabled him to inflict a crushing defeat on the Maratha Army.

Another incident involving the problem of a river-crossing illustrates the result of a deficiency of engineer intelligence. In the opening phases of the Great War, the German Ist, IInd and IIIrd Armies first encountered the allied main armies standing on the line of the Meuse, Sambre and Mons Canal. On August 23rd the IInd Army had crossed the Sambre between Namur and Charleroi, and were pressing on to the French Vth Army, established on the heights south of the river, with their right flank resting on the Meuse. The German IIIrd Army, on the left of their IInd Army, was advancing towards the Meuse, almost at right angles to the French line. By a rapid movement across the river they would be able to outflank the French Vth Army, or at all events, very seriously hamper their withdrawal, while the IInd Army engaged them frontally. Accordingly, a special composite division was formed under Colonel von Olnhausen, with orders to cross the Meuse at Fumay and advance on Rocroi. The essence of the operation was rapidity, to

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cut off the French line of retreat. On August 24th, von Olnhausen beat back the French troops protecting the bridgehead at Fumay, only to find the bridge demolished. He had no bridging equipment with his force, so a crossing there was impossible. He therefore marched eight miles south to the next bridge, at Revin, by forest tracks and bridle-paths, which delayed him considerably and exhausted his men and animals, only to find the bridge there, too, destroyed. Actually the division did not cross until August 27th, when the remainder of the main army came up, with its pontoon equipment. By that time the French had disengaged and the chance of cutting their communications was lost.

The non-provision of bridging equipment can only be attributed to a lack of engineer foresight, or intelligence, as it may be called; the march over bad roads may, or may not, have been due to lack of engineer information, but in any case it was unnecessary, had the value of engineer reconnaissance been appreciated. If the Commander had dispatched a strong reconnoitring party and first ascertained if the bridge at Revin was intact, he need never have undertaken the fruitless and tiring march.

A third incident shows that the importance of careful dissemination of intelligence is just as great as the necessity for collecting it. The engineers of part of the American forces engaged in the operations to cut off the German salient at St. Mihiel, in September, 1918, were ordered to accompany the infantry, and carry bridges for the crossing of the Rupt-de-Madt, a small stream running across the front of attack. The stream ran in territory which had been occupied by the Germans for the last four years and, when reached, was found to be very insignificant and to form no obstacle to infantry. It was discovered later that the General Staff was in possession of intelligence which would have given the engineer commander sufficiently accurate information to have enabled him to avoid this waste of man-power, but, through faulty recording or distribution, it failed to reach him.

From a study of these historical examples, a definition can be framed which will serve as a guide in discussing its value and acquisition:—" any information regarding the theatre of war, the enemy's methods, and their own experiences which will enable military engineers to prepare for and carry out their work in such a way as to render the maximum possible assistance in the attainment of victory."

In the second illustration described, had the responsible engineer commander considered the probable action of the French engineers, he must have realized that the chances of finding the bridges over the Meuse intact were very small. Again, in the third illustration, had the engineer commander been in possession of information regarding the Rupt-de-Madt, he would have been able to allot to

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his troops more useful work for the furtherance of success of the operations. Under the heading "their own experiences" is included the result of training, study and keeping abreast with developments in engineering science.

It is unnecessary to dwell on the need for the fullest information possible being transmitted to engineer commanders in good time to enable them to draw up their plans for the provision of necessary materials and labour, and to guide them in deciding on the relative urgency of the demands upon their resources. The preliminary investigations and calculations to be made before undertaking any engineer work in peace cannot be too carefully worked out, and if the best use is to be made of engineer troops in war, it is imperative that their commanders be supplied with as ample and accurate information as possible to give them a basis on which to make their preparations for work.

Only an outline of such information required can be given here. New developments in armament and their corresponding effect on the work of engineers must be anticipated. For instance, the extensive use of tanks and mechanical cross-country transport will render the study of terrain and possible obstacles very much more important than formerly; river-beds and crossings, too, must receive special attention. The introduction of aircraft has taught us the necessity for concealment from aerial observation, and we shall need information regarding the vegetation or crops in order to be able to make preparations for camouflage of works or concentrations.

The principal headings under which Engineer Intelligence will be required, then, are :—

Roads.—Class, nature and width; state in winter; sources of material for repair; strength and dimensions of bridges.

Waterways.—Crossings; bridges or fords; strength of current; practicability of floating or pier-bridges; dimensions in summer and winter; floods; possibility of use for transport or communications.

Water Supply.—Reservoirs and pipe systems; wells and springs; geological formations.

Engineer Material and Plant.—Factories, workshops; machinery, tools and engineer stores; timber resources.

Power.—Electric installations and circuits; coal; gas.

Communications.—Railways and rolling stock; telephones and telegraph systems.

Fortifications.

Foreign Armies.—Engineer methods and organization; stores and designs.

Civilian Labour and Transport.

Terrain.—Geological conditions affecting earthwork and mining; possible defensive inundations; whether open or enclosed; nature of vegetation; ravines, nullahs and other obstacles.

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Such detailed information can only be obtained in the leisure and comparative freedom of movement of peace; and, though a great deal can be gathered by the study of technical publications and other books, as will be shown later, for satisfactory results personal visits to the various possible theatres of war are necessary. This is an expensive proposition, and, in deciding upon the most efficient means of acquiring intelligence, the need for economy must not be lost sight of.

The possible sources of information are more numerous than might appear at first sight, if advantage of them all is taken :—

1. *Technical Publications.*—Engineering, commercial or scientific handbooks and periodicals, or even guide-books and photographs, will often provide information and statistics regarding local engineer conditions and resources. For instance, an article in an engineer journal may give all the information required about certain factories or works. Intelligence thus obtained will, of course, often require confirmation or amplification, and, conversely, may be extremely valuable as confirmation of information obtained from other sources.
2. *Agents.*—Of intelligence agents it is unnecessary to say more than that this will be the principal source of information required on particular points. As the size of armies grows and mechanical devices form an increasingly important part of their armament and equipment, so the importance of engineer intelligence becomes greater, and it is very desirable that all agents should have sufficient knowledge or training to enable them to carry out useful engineer reconnaissances.

   Private individuals, too, whether themselves travelling, or by correspondence with others in foreign countries, may be able to render valuable assistance. Germany exploited this method to a great extent before the Great War, and there is little doubt that, as far as the continent was concerned, her activities in this direction stood her in good stead. It is particularly engineer officers who can assist, and, if only for practising themselves in making engineer reconnaissances, they would render their country a great service by always noting—and subsequently reporting—any engineer information that strikes them in the course of their travels.

   The names of individuals who are known to be familiar with certain localities should be noted, in order that reference may be made to them if information is subsequently required on any particular point.
3. Consuls and Attachés are in a position to collect much useful information concerning the country in which they are serving,

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and its army. This source, however, should be approached delicately.

4. Foreign army text-books and training manuals are the surest means of ascertaining the methods of troops of foreign countries, and should invariably be studied carefully, if we are to be on guard against the actions of the enemy in war.

In war, the collection of intelligence is simplified in that the areas or armies concerning which we require information are defined, and we are able to concentrate our efforts. On the other hand, the results obtainable from all the above-mentioned sources will be considerably diminished: publications will be difficult to obtain, the activities of agents and communication with them will be very much more difficult, the third source will be non-existent and the fourth limited to documents captured in the course of fighting. In fact, we can hope for little more than to keep up-to-date the information collected in peace, which strengthens the contention that, if we are to be well served with intelligence in war, we must obtain it in peace and base our preparations on information so collected. The principal sources will be:—

1. *Aerial Reconnaissance.*—Though of no great value as regards details, a great deal of information regarding new works, railways and roads, fortifications, bridges, engineer stores and even telephone systems can be obtained from aircraft, and especially from aeroplane photographs.
2. *Refugees and Prisoners.*—A doubtful source, depending upon the knowledge, veracity and communicativeness of the examinee; but, if he is treated in the right way, very valuable up-to-date information can be extracted.
3. *Civil Engineers of Municipalities, Districts.*—If accessible, this source is of first-class value, as probably all engineer conditions of the locality will be known by these officials.
4. *Engineer Reconnaissances before, during and immediately after battle.*—This is a part of the ordinary duties of engineers and will be referred to later.
5. *Captured documents and works* take the place of peace-time training manuals and keep us up to date in development of the enemy's methods.
6. *Our troops' experiences.*—Just as in peace the study of engineering progress enables us to keep our methods, training and equipment up-to-date, so we must make use of the lessons learnt during the campaign. Developments, which cannot possibly be foreseen in peace, are sure to arise and these will cause us to modify our methods as we gain experience.

It has already been shown that equally important as the collection of intelligence is the collation, recording, indexing, revision and

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distribution of it. If it is to be of any use at all and justify the labour and money expended in its collection, intelligence must be readily available to the man on the spot where and when he requires it. In the final distribution there are three principal dangers to guard against; firstly, to avoid excessive secrecy and thus prevent information from reaching those who should be in possession of it; secondly, to avoid issuing in piecemeal form, badly indexed and therefore difficult of reference on any particular point; and thirdly, that information is not tucked away and lost sight of.

What, then, are the processes through which information transmitted to any responsible headquarters should pass?

1. *Sifting.*—The reports must first be reviewed and the useful portions picked out; that requiring confirmation and amplification must be noted. Technical experts should be referred to, as they only can say what is likely to be of use; the non-technical mind often does not appreciate the small details and clues which may make all the difference to an engineer.
2. *Collation.*—The relevant matter must then be arranged, reports on the same subject from different sources combined in concise form.
3. *Indexing.*—It is at this stage that the danger of losing track of information must be guarded against, by very careful recording and indexing. Only by this means is it possible to extract certain information when required for reference or for revision when corrections are received.
4. *Publication.*—In peace, information will normally be collected systematically and compiled for publication in book form, or on intelligence maps. In war, however, it may be necessary to supplement this by the issue of information as soon as possible after its receipt, in which case the preparation for publication would coincide with the second phase described above. For instance, certain information may come to hand just before battle, the publication of which would give our commanders valuable assistance in finding the enemy's "soft spots," or, as was often the case in the Great War, it was important to issue descriptions of German mine traps as quickly as possible in order that the engineers might be on their guard against similar devices. It will readily be seen that such piecemeal publication complicates records and indexing.

   The form of publication is important. There is little doubt that the most efficient form of issuing intelligence regarding possible theatres of war is on maps. The information stands out clearly and enables a picture of the country to be formed quickly in one's mind's eye, and, above all, hunting through

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indexes and pages is avoided. For large areas and detailed information, the cost and bulk of such maps would be prohibitive and information must be issued in book form (very well indexed).

Finally, there are pamphlets, circulars and plates issued from time to time. These must be very carefully numbered in series, according to the subject dealt with, for the convenience of the recipients and recorders. The form of publication requires careful consideration, and it should be remembered that large sheets of paper are inconvenient for binding and carrying, and are therefore often tucked away and forgotten. It is the duty of the compilers to reduce to a minimum the possibility of this danger by issuing their publications well numbered, and in form easily bound for reference.

5. *Distribution.*—The factors governing the scale of distribution are :—

(*a*) Everyone to whom the information may be of use must receive it.

(*b*) Too wide a distribution leads to lower formations and units being " snowed under," and consequently much is pigeon-holed and lost sight of when required.

(*c*) Much intelligence is of a highly confidential nature and its wide dissemination is most undesirable.

The weighing of (*a*) against (*b*) and (*c*) and decision as to the final distribution should rest with an officer of considerable experience, and, here again, it is essential that the advice of technical officers be taken regarding matters affecting their branch. A solution of the difficulty of avoiding excessive distribution is to issue lists of Intelligence publications, with brief summaries of their contents, to all who could possibly be concerned. These lists would then be filed with intelligence on connected subjects and the publication (map, book or circular) could be at once demanded when required.

The treatment of Intelligence generally has been discussed up to this point, and the special organization and treatment of Engineer Intelligence must now be considered. The principles on which to base our organization are :—

i. Technical efficiency.
ii. Economy.
iii. Equally applicable to peace and war conditions.

In the definition of intelligence put forward it has already been remarked that there are three main divisions : information concerned with foreign or enemy countries ; engineer practice and progress at home and abroad ; and that concerned with or available in our own territories.

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In the case of Intelligence concerning foreign countries (which is the largest and most important division) it is impossible to draw a hard and fast line between Military Intelligence, as required by the General and Administrative Staffs, and Engineer Intelligence as required by the Royal Engineers; full information regarding roads, fortifications, water supply, rivers and other obstacles are equally important to one as to the other, though naturally the R.E. require greater detail in some cases, and it will be economical and efficient if the collection of such information is entrusted to one organization. Further, since the Intelligence branch of the General Staff possesses the machinery (intelligence agents) to do this, it is indisputable that all the groundwork of this portion of the collection be entrusted to them. A special engineer intelligence service could not justify its cost and, moreover, overlapping and the danger of "E" and "I" working in watertight compartments and not sharing the results of their labours would be sure to arise. This does not, however, relieve engineer staffs of the responsibility of informing "I" of any particular information which they require, giving advice as to particular points to be specially investigated, and suggesting sources of information. This necessitates the maintenance of a very close liaison between "E" and "I"; in fact, there should be one engineer officer detailed (either assisted by a staff or as part of other duties, according to the size of the formation and the volume of intelligence work dealt with) whose duty it is to review all information collected by "I" which could conceivably be of use to engineers, and to recommend the scale of its distribution. He will also be able to advise "I" as to points on which confirmation or amplification is required; for instance, it is not sufficient to know that so many wells exist in a certain place—we must know the yield and depth.

In war, too, this officer should be able to examine refugees and prisoners, or, if unable to do so, should give the intelligence officer very definite instructions as to the questions to be put to the examinee. He must have free access to all aeroplane photographs, and be expert in their interpretation, and through "I" inform the R.A.F. of any particular way in which he requires their assistance. Engineer staffs must give "I" very exact details of information they require from agents. For instance, in the case of masonry bridges, they must detail the measurements required: span of bays, number of bays, thickness of arch, width of roadway, dimensions of piers. The value of any technical information supplied in peace by engineer officers regarding foreign countries, to supplement that obtained from "I", will now be readily recognized.

"I", however, cannot be expected to judge of the value of technical information contained in books on foreign countries' engineer methods and organization, and it is the duty of engineer

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staffs to extract such information. This now forms part of the duties of the R.E. Board at the War Office and the machinery so set up could hardly be improved upon. It is for consideration whether the duty of translating foreign technical publications should devolve on "E" or "I"; though not strictly engineer work, it is desirable that an engineer officer should do this, as there is then less danger of misunderstanding technicalities.

Engineer intelligence regarding our own country, or territories occupied by our army in war, and of civil engineering progress falls in the province of engineer staffs. They only are in a position to know how and where such information they require is obtainable, and as it is quite distinct from the military intelligence required by the G.S., "I" is not concerned. In peace, this, too, is fully dealt with by the R.E. Board. In war one of the most reliable sources of information regarding local engineer matters are the civil engineer officials of occupied territories, and it is important that engineer staffs establish close touch with them. Even so, to supplement information from all other sources, engineer reconnaissances will be constantly made, and, particularly on an advance of our armies, one of the most important and primary duties of the R.E. is the execution of rapid and thorough reconnaissances. It is unnecessary to go into details, as the subject is fully dealt with in all engineer training manuals.

To sum up, the collection of engineer information regarding territories up to our own frontiers (or the firing line in war) and technical information extracted from publications is the duty of engineer staffs, and regarding all countries beyond our occupation, it is the duty of the intelligence staff.

In compilation and publication the dangers of duplication and lack of co-operation are even greater, and demand a still closer liaison between "E" and "I." To avoid these dangers, all intelligence including such engineer intelligence as is of use to the army as a whole, should be taken charge of by "I," while purely technical intelligence, as, for instance, geological or electrical information, is dealt with by "E." The "E" liaison officer, therefore, should see all information coming into "I's" hands and, conversely, all information obtained by "E" in their sphere of activities regarding fortifications or roads, and other such matters interesting the General and Administrative staffs, should be passed on to "I." The publication of information thus compiled should be guided by the same principles and it would appear advisable that purely engineer information regarding foreign or enemy countries and their armies, though collected by "I," should be issued by engineer staffs. Both staffs must know exactly what the other has issued and should include the other's publications in their own records and index; otherwise overlapping is bound to occur.

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Attention has already been called to the necessity for "I" to consult engineer staffs on the distribution to R.E. commanders and units.

In the British Empire we are confronted with a particularly difficult problem. The defence of our scattered territories may involve us in operations in almost any part of the world; or, at all events, we cannot afford to remain in complete ignorance regarding the greater part of it. The most satisfactory and economical solution appears to be to relieve the Imperial Forces of the collection of as much as possible of the duty of collecting intelligence over this vast area by delegating to the headquarters of the military forces in India and the Dominions the responsibility for dealing with countries adjacent to them. This, too, is consonant with the increasing self-reliance of the constituent parts of the Empire. Uniformity of organization and methods, and a full interchange of intelligence is of paramount importance, and it is suggested that by these very means mutual sympathy in all matters affecting the relations, both civil and military, between the various governments would be strengthened.

A summary of the proposals for the organization put forward will be most clearly shown in tabular form. But, at a risk of calling forth an accusation of repetition, it is again pointed out that the essence of an efficient service of Engineer Intelligence lies in liaison between "E" and "I," and only by maintaining it shall we avoid finding ourselves in the lamentable state of lack of information in which we were placed in the early stages of the Great War.

Subject.	*Collection.*	*Compilation and distribution.*
Foreign Countries (*a*) General, including military engineer matters	"I," advised by "E."	"I"
(*b*) Technical	" "	"E"
Engineering progress and methods at home and abroad, military and civil.	"E," with any assistance possible from "I."	"E"
Engineering information and experiences in our own territories	"E," handing anything of interest on to "I."	"E"

As our standing army is reduced, so we can only ensure efficient action when necessity arises by improvements in organization, equipment and preparations to enable us to meet the most probable dangers. This can only be affected by constant experimental and intelligence work, such as is directed by the R.E. Board, progressing hand in hand, and any undue curtailment of expenditure on these activities would indeed be false economy.

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MODERN ROAD ENGINEERING.

A Lecture delivered at the S.M.E., Chatham, on 9th November, 1922, *by* Mr. H. PERCY BOULNOIS, M.INST.C.E., F.R.S.I., *etc., etc.*

THE birth of Modern Road Engineering dates from the advent of self-propelled traffic, about the year 1890.

It was the outcry against dust, flung into the air by the fast-moving vehicles, that initiated the experiments and trials, with coal-gas tar and other compounds, which eventually resulted in a complete revolution in road construction.

It was found that, not only did certain compounds act as dust-palliatives, but that some of them, especially tar and heavy oils, possessed the quality of binding the materials of which a water-bound macadamized road is formed, thus preserving the surface against the wearing effect of traffic, but that it also sealed the surface and prevented the infiltration of water which, in some cases, is almost as damaging as the traffic.

The satisfactory results thus obtained led to the use of tar, or similar bituminous compounds, as binders instead of water and grit, which had been used since the days of Macadam and Telford. I shall speak of these methods later on, but before doing so I must deal with the question of tar-spraying in some detail, as this method of treating our road surfaces must continue for many years to come. Not only are the majority of the roads of the old water-bound type, but this method is also necessary, from time to time, on modern roads in order to keep their surfaces sealed.

In the early trials, to which I have referred, crude gas tar was heated and poured on to the road out of cans and then brushed over the surface with brooms or with squeegees, but now more scientific processes are adopted.

Dry weather is essential, as the least wet, or even damp, will prevent the adhesion, or penetration, of the tar or other compound. The whole object of the treatment would thus be defeated. Before the tar is applied, the surface of the road must be swept and cleansed of all dust, dung, caked mud, etc., any pot-holes, or irregularities of the road should be repaired and made good.

A final sweeping of the surface, with hair brooms, just in front of the tarring operations, is very desirable to ensure adhesion and penetration.

Crude tar contains ammoniacal liquor, light oils, naphthalene, and

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other impurities which must be removed before tar can be used for this purpose.

Much might be said as to the proper chemical composition of the tar, or other compound, but time will not permit. Suffice it to say that the late Road Board prepared, and issued comprehensive specifications on the matter which are published by Waterlow & Sons, of London Wall, E.C., and if any of you wish to study the question further I must refer you to them.

The application of the tar to the surface requires some skill, for, if too much is applied, it collects in puddles, does not dry off quickly, and so saturates the road that the tar will exude in hot weather and cause trouble. On the other hand, too little tar will not ensure proper penetration.

There are now numerous ingenious machines on the market which spray or spread the tar either by gravity or under air pressure of about 180 lbs. on the square inch. For the latter it is claimed that the tar is atomized and is thus forced into the interstices, thus securing proper penetration and also uniformity of spread. It is also claimed that, as the tar is delivered at a temperature of 250 degrees Fahr., the hot air mingled with the tar, under this pressure drives off any dust that may remain on the surface. Expedition is also necessary on account of the traffic, and some of these machines are capable of covering 1200 square yards of road surface a day, using from 4 to 5 gallons of tar per square yard of surface. Where there is any risk of polluting any stream, or river, with the tar, precautions must be taken to prevent it by stopping up any gullies or outlets with sacks or by other means. At one time it was thought that these bituminous compounds poisoned the fish, but recent investigations revealed the fact that this is not generally the direct cause, but that certain vegetation and animalculæ on which the fish feed, are killed, and thus the fish are starved. One other point, and that is that so long as horses use the roads precautions are necessary to prevent the road becoming slippery. This is generally effected by "dusting" the surface, after tarring, with sand or other suitable material, of about $\frac{1}{8}$ to $\frac{1}{4}$-inch gauge. Some road engineers contend that this practice is detrimental as the particles of sand, or other material, are forced, by the subsequent traffic, through the skin of tar, thus breaking the seal and letting in the water. On the other hand, this "dusting" helps to dry off the tar, forms a thicker skin, and prevents the surface becoming slippery. Some judgment is therefore necessary, though on steep gradients it is advisable to practise this dusting. Having thus far dealt with what may be called the temporary improvement of the surface of roads, I will now turn to some of the problems which confronted the road engineer when the extraordinary revolution in the traffic took place.

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The permanent way engineer of a railway knows exactly what is expected of his road, he knows the weights and speeds of the various trains. He is fully cognisant of the behaviour of his rails, their composition, design, and construction, to meet his requirements, and, as a rule, he is not handicapped by want of funds. The road engineer, on the contrary, entered into a hitherto unexplored region of engineering with little to guide him. He found the existing roads incapable of standing up against the altered traffic. How were they to be reconstructed, or strengthened? For what weights and speeds should provision be made? What materials should be selected for their reconstruction or repair? What was to be done about the acknowledged weakness of most of the roads, and what could be done with their bad foundations? Should the roads be widened, and, if so, to what extent? How were awkward corners to be dealt with? And last, but not least, where was the money to come from?

These and other problems confronted the County, Municipal, and Local Surveyors throughout the country and manfully they were tackled, although the Great War sadly hampered their efforts. Dealing shortly with some of these problems, it was found that the dynamic shock of a self-propelled vehicle is greatly increased by the speed at which it travels. In addition to this it was found that there was a brushing, or scouring, action on the surface of the road by the pneumatic tyres of a car travelling at high speed, or in changing speed, and also a side, or lateral push, of the wheels in turning corners. It was discovered that the vibrations set up by a car produced a movement amongst the stones, of which a road is formed, to a considerable depth. This movement caused inter-attrition of the stones, thus rounding them off, and preventing the interlocking, or binding, of the materials of which the road is formed. This showed that even the submerged materials required some thicker, and more resiliant, binding material than water and grit. This quality was found in the bituminous compounds of which modern roads are now constructed. It was soon observed also that fast motor traffic tended to produce ruts, as the drivers preferred the centre of the road for purposes of safety against vehicles emerging suddenly from side roads, etc.

Other questions arose affecting the wear of roads, such as the proportion of the width of tyres to diameter of wheels, the damage caused by metal tyres, especially those fitted with diagonal bars, and also the squeezing effect of twin rubber tyres. The "wabbling" motion of heavily loaded trailers was also found to cause some damage.

All these questions, and others, were carefully studied and investigated, with beneficial results.

With regard to width of roads, as affected by the altered traffic, in the horse-drawn vehicle days the best width of the carriage-way

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was found to be a multiple of 8 ft., as in that width vehicles could safely pass each other. The Bye-Laws regulating the width of new streets fixed the minimum width at 36 ft., of which 24 ft. was carriage-way with a 6 ft. footpath on each side. Modern traffic, however, requires greater width, not only on account of greater speeds, but also because the width of some vehicles has increased to 7 ft. 6 in. over the axles, and consequently the multiple should be raised to at least 10 ft. The new arterial and trunk roads, now in course of construction, are, some of them, being given a width, between the properties on each side, of 100 ft. divided as follows: two carriage-ways of 30 ft. divided by a strip 20 ft. in width (to be ultimately utilized for a tramway or planted out with trees and shrubs) and a foot-path 10 ft. in width on each side of the whole road.

Intersections of roads and corners require special treatment with the object of securing liberal space and a clear view for the drivers. In order to minimize the effect of the lateral thrust of motor-cars at corners, it is now the practice to give a super-elevation of the road on the outside edge, the same formula being used as that on railways, the speed being assumed at 50 miles per hour.

Gradient is not of so much importance as formerly, as most self-propelled vehicles make light of hills. In the case of impervious surfaces, however, the gradient should not exceed 1 in 18, on account of slipperiness.

The question of camber is important. As a rule the camber is excessive on our roads, and in some cases even dangerous. The object of camber is merely to secure a proper "run off" of the water, so that with modern impervious surfaces the camber may be considerably reduced from that which was necessary with comparatively rough surfaces. My own opinion is that the following gradients for camber would be now sufficient :—

Natural Rock Compressed Asphalt ...	1 in 60
Wood Pavement	1 in 50
Granite Setts	1 in 45
Tar Macadam, etc.	1 in 40
Tar-sprayed Macadam	1 in 40
Ordinary Water-bound ditto	1 in 36

A good deal might be said about the importance of the foundation of roads and the necessity of thorough drainage of the base, etc. Also as to the need of supporting the haunches with kerbs, submerged concrete walls, large stones, or other means to prevent the lateral spreading of the road, but time will not permit.

I will now pass on to deal with some of the modern methods of road construction which have been introduced to meet the requirements of which I have spoken.

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These may be enumerated as follows :—

1. Pitch Grouting.
2. Tar Macadam.
3. Tar Slag.
4. Asphalt or Bituminous Carpets.,
5. Unsurfaced or Bare Concrete.

1.—Pitch Grouting.

This method may shortly be described as follows :—

Ordinary broken macadam, of suitable gauge, is laid on a consolidated road after hacking, or on a newly constructed hand-pitched foundation, and rolled to a consolidated thickness of 2½ in. to 3 in. A hot tar or pitch mixture is then poured over the surface and brushed into the interstices. Care must be exercised to see that the stones, to a depth of at least 1½ in., are absolutely dry. This used to be done by hand buckets, or cans, pouring the tar on to the road, but is now effected in a more certain and expeditious manner by a tar-boiler on wheels delivering the hot mixture direct on to the road. There are a number of " recipes " for the pitch mixture, but generally it consists of carefully prepared tar, pitch, and creosote oil, heated to about 300 degrees Fahr., to which is added heated dry sand in such proportion as will allow the mixture to flow readily into the stones so as to come up to within ½ in. of the surface. The road is then sprinkled with small stone chippings whilst light rolling proceeds. Care is necessary with this method of construction or failure will follow, due to faulty mixture, faulty " cooking," dampness of the surface or stones, insufficient penetration, too rapid cooling and setting of the " mixture," or the unsuitability of the stones for proper adherence.

2.—Tar Macadam.

This may be taken as the earliest form of modern road construction. Broken stones were heated on thin iron plates supported on low sleeper walls with a fire underneath, the stones being turned over with hand forks until thoroughly dry and hot. Then hot tar was added and the mass was turned over and over, until each stone was coated with tar. This was then carted to the road, spread on it, and rolled to the required thickness. Modern machinery effects this process in a much more satisfactory and expeditious manner, ensuring proper proportions, thorough coating of the stones, and proper temperatures.

The late Road Board prepared some General Directions for Surfacing with Tar Macadam which I don't think were published, the main points of which are as follows :—

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The road should have a proper foundation, or sub-crust.

The consolidated thickness of the tar macadam should be not less than three inches, according to traffic requirements. For a greater thickness it should be laid in two coats.

The aggregate should be composed of broken stone of approved quality and consist of 60 per cent. of 2-in. standard gauge, 30 per cent. of 1½-in. standard gauge, and 10 per cent. of ¾-in. to ½-in. chippings should be used for filling the voids during rolling operations. In the case of two-coat work the sub-crust should consist of 2-in. standard gauge stone, the wearing surface of 1½-in. ditto with 10 per cent. of chippings as before. The stone to be absolutely dry. The tar to be in compliance with the Board's Specification Tar No. 2 and be heated in a boiler specially designed to prevent frothing, which inevitably occurs if the tar contains even a small percentage of water. The desired temperature is generally found to be between 260 degrees and 280 degrees Fahr. in the boiler or heater. The quantity of tar used to coat one ton of stone varies from 9 to 12 gallons, according to the gauge of the stone and method of mixing. Less rolling is required than for a water-bound macadam road; a 10-ton roller is ample for the purpose. After the road has been subject to the traffic for some weeks it is advisable to apply a coating of about one gallon of tar to every 6 super yards of road surface, sprayed on at a temperature of about 270 degrees Fahr. For gritting it is recommended that stone chippings, crushed gravel, coarse sand, or other suitable material, free from dust, not larger than will pass through a ¼-in. square mesh, should be used. It is further recommended that the tar should be tested by a qualified Analytical Chemist before being used.

3.—TAR SLAG.

Selected Furnace Slag is an excellent substitute for the manufacture of Tar Macadam. It must, however, be carefully selected; the most suitable is said to be that which contains about 40 per cent. lime, 40 per cent. silica and 20 per cent. alumina. It should weigh not less than 25 cwt. per cubic yard and have as little honeycombed appearance as possible. There is an excellent material of this description on the market known under the trade name of "Tarmac." In this case the slag is taken direct from the furnace, allowed to cool to a certain temperature, then broken to suitable sizes, and whilst at this temperature is plunged in hot tar.

It is claimed that as the slag is taken direct from the furnace it is perfectly clean, that the intense heat has reached the very centre of it without damaging the structure, that every drop of moisture has been driven out of it and that the tar has entered all the crevices and voids.

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Mr. Purnell Hooley, the late County Surveyor of Nottinghamshire, is the discoverer of this method which he patented. It proved so successful that there are now many miles of this method of construction all over the country.

4.—Bituminous Carpets.

I believe I ought to call these *Asphaltic* Carpets, as modern nomenclature has reversed these names; what I have always known as Bitumen is now called Asphalt, and *vice versa*. However that may be, this description of road surfacing is the most modern of any system that has yet been introduced. It may shortly be described as a fairly thin coat of a very carefully-graded mixture of sand, pulverized stone, or powdered mineral matter, and specially prepared bitumen, carefully mixed together in pre-arranged proportions at certain temperatures. When finished it appears to approach the composition of natural rock asphalt. The grading of the sand, or other materials, and the proportions, require great care, and they must be absolutely clean, dried and heated to a certain temperature, generally about 330 degrees Fahr.

Time will not permit me to give you the numerous "recipes" that exist for the manufacture of these carpets, but the following will give you some idea of the care necessary in proportioning the various sizes of the materials:—

In this case the material was sand.

10·7	per cent.	passing	100	mesh	sieve.
15·7	,,	,,	76	,,	,,
45·7	,,	,,	50	,,	,,
10·0	,,	,,	40	,,	,,
10·6	,,	,,	30	,,	,,
4·6	,,	,,	20	,,	,,
1·5	,,	,,	10	,,	,,
1·2	,,	,,	10	,,	,,

A "filler" of either Portland Cement, or fine dust of a mineral nature, was added to the extent of 9 per cent., and to this was added 13 per cent. of bitumen to 78 per cent. of the mixture.

This description of road surfacing is generally laid in two coats, the lower one being made of rather coarser material than the upper, but the total thickness of the two coats, when consolidated by rolling, rarely exceeds three inches.

The selection of the bituminous, or asphaltic composition, requires great care, and consequently a number of tests are made before selection. These are carried out with special instruments designed for the purpose. It would take too long to describe the process of these tests and the interpretations to be gained therefrom, but

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you may judge of the amount of laboratory work involved by the following list of some of the tests that have to be made :—Specific gravity ; solubility in carbon disulphide ; viscosity ; determination of the fixed carbon ; evaporation ; the melting point ; the flash and burning points ; ductility ; and toughness. If any of you require further information as to the instruments to be employed I must refer you to "*The Testing of Tars and Pitches for Roads*, by John Hutchinson, to be obtained at the offices of *The Surveyor*, 34, Bride Lane, E.C.4.

It is not everyone who has the time or knowledge to make these tests or the necessary machinery for the manufacture of these carpets, but fortunately various materials or compounds can be obtained under trade names which are thoroughly reliable and meet all the requirements for the construction of good roads.

Before passing on to concrete roads, a few words are necessary with regard to waves and corrugations which so frequently appear on the surface of bituminous roads after a short spell of traffic. These deformations are sometimes attributed to the action of the rollers, especially if too heavy ; others contend that variations in temperature are the cause, or that the fault lies with the material or method of laying ; others, that it is caused by the rhythmic action of the motor traffic, in the same manner that the wind produces waves on the sea. No doubt there are many contributory causes and that, as observations are made, these will be discovered and a remedy found. My personal view is that the initial rolling is the primary cause, and that careful cross-rolling with lighter rollers will go far to prevent this blemish.

5.—Unsurfaced, or Bare Concrete.

Although this description of road has been made in America and Canada for many years it has not found much favour here for various reasons.

Objections were raised as follows :—

The necessary diversion of the traffic for three or four weeks whilst the concrete is setting ; the hard character of the surface causing noise from metal tyres and jarring of horses' hoofs ; its liability to crack when laid in monolith ; the difficulty of opening up for the laying of gas, water, or other pipes, especially if the concrete is reinforced ; the liability to become dusty ; the careful and constant supervision necessary during construction to secure satisfactory results ; doubts as to its length of life, as this method of construction is too recent to form an opinion.

As I have been a rather persistent advocate of concrete roads, I will deal with these objections.

Undoubtedly, concrete must be allowed three or four weeks to

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set before traffic is allowed on it, but arrangements can often be made to divert the traffic, and judgment is necessary in selecting the neighbourhood for this description of construction. Concrete is not intended to supersede other systems, but only as a substitute where found desirable. As to noise, I think that metal tyres will gradually disappear and no doubt horses will become scarcer on our roads. With regard to cracks, these can be absolutely abolished if the concrete is made, and laid, by machinery to a rigid specification. As to the difficulty of breaking it up, it is exactly the same with all paved streets with concrete foundations, the recent introduction of pneumatic drills has considerably reduced the labour and cost of this operation. As to dust, if this is feared, it is easy to tar the surface and thus prevent it. With regard to the care and supervision necessary, it is perfectly true that unless this is exercised failure will follow I am, however, often struck with admiration at the wonderful manner in which concrete behaves after the careless manner in which it has been made and laid. A rough banker of boards, on which it is mixed with inferior cement, recklessly proportioned; the aggregate of gravel, or broken stones, probably not very clean, the water slopped on in too abundant quantity, as the wetter the concrete is the more easily does it slide off the shovel. If concrete can stand such treatment and yet behave as it does, it is evident that with skilful treatment much more may be expected of it.

Time will not permit me to give you a specification of the right manufacture of concrete for road construction, but if you desire further information on the subject I must refer you to my recent book entitled *Modern Roads*, published by Edward Arnold. There are now concrete-mixing machines on the market by which the proper proportions of the ingredients, aggregate, cement, and water are absolutely secured, as well as thorough blending. Concrete should be placed *in situ* as speedily as possible after mixing. A bed of dry ashes, or similar material from 3 in. to 4 in. in depth should be placed on the surface of the excavated ground on which the concrete road is formed; this prevents the adhesion of the concrete to the soil and minimizes one of the chief causes of cracking. After the concrete is laid, finished off and screeded, it should be protected for some weeks by a covering of canvas sheets, or 3 in. or 4 in. of earth, saturated with water, in order to prevent too quick evaporation. Reinforcement is desirable where heavy traffic is anticipated or the ground is treacherous. It distributes the unequal pressures of the weights and consequent shocks and stresses due to the moving loads. It also assists in preventing cracks and so strengthens the concrete that less thickness is required, thus saving material and excavation. (Here the lecturer showed a model of the Walker Weston method of reinforcement and explained it.)

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As to the last question, that of probable length of life, we have not at present much to guide us, but I know a road in Kent, constructed about eight years ago, in a rather perfunctory manner, during bad weather, and adverse traffic conditions, which has received no repairs and yet appears to be in practically the same condition as when constructed, though subjected to very heavy traffic. Look also at some of the, so-called, artificial concrete flags laid on foot-paths which last as long, or longer, than York or other natural stone flags. I have walked on a promenade paved with Purbeck marble where the foot traffic had so worn this hard stone that the cement joints stood up like knife-edges, at all events, showing that cement had worn better than this stone.

With regard to other forms of road construction: improvements have been made in granite setts so that they can be laid closer together owing to more careful dressing, thus reducing noise, the bugbear of this class of pavement.

Durax, or small stone cubes, have been laid with varying success, but do not appear to stand against heavy traffic unless laid on concrete, which considerably adds to the cost, so that ordinary setts might just as well be used. Soft wood creosoted blocks still hold their own as a good street pavement, when laid on a sufficiently strong concrete foundation, and it is difficult to see where a substitute is to be found. There is some talk of rubber, but the excessive cost is against it and also the difficulty of getting it to adhere to any foundation. (Here the Lecturer showed samples of the "Gould Rubber Block," but said the cost was at present too great for practical road-making.)

I have said but little, in my lecture, about the numerous and varied machinery and plant now required in modern road construction, but such a subject would require a lecture in itself to do it justice.

I have endeavoured, however, to show you how Modern Road engineering has altered in the last few years. Much has been done in the past, but much remains to be done in the future. Engineering knows no finality and advances in science and practical application go hand in hand. It has been wisely said that "When an Engineer ceases to learn, he ceases to be an Engineer." This is perfectly true, for after a long and strenuous life of engineering I begin at last to realize my ignorance.

I will now show you a few slides to illustrate some of the points of my lecture and then, through the great courtesy of the Limmer & Trinidad Lake Asphalt Company, you will be shown a cinematograph illustrating the digging of the bitumen out of the celebrated Trinidad Lake, and following up the various processes of refining and preparation of the bitumen, its final spreading, rolling and completion, and the traffic such roads have to bear.

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The following is a list of the slides shown on the Screen and explained by the Lecturer :—

1. Type of pressure tar-spraying machine.
2. Type of gravity tar-spreading machine.
3. Spreading tar with hand-pressure machine.
4. The same machine showing horse quickly liberated in case of fire.
5. Detail of hand-spraying pump.
6. Type of trailer gritting machine.
7. Tar boiler grouting machine.
8. Midget patching outfit.
9. Double drum drying plant for tar macadam.
10. A quick reversing steam roller (6 tons).
11. A 7-ton petrol roller.
12. Pneumatic drill picking up bituminous road surface.
13. Ingersoll drill breaking up concrete.
14. The same, showing work in Ludgate Circus.
15. Type of handy air compressor for above drills.
16. " Aero " concrete mixer fitted with " caterpillar " wheels.
17. Type of complete plant, mixing concrete, and laying it on the road, with moving template and screeds.
18. Detail of the above template.
19. A complete concrete road in America.

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A METHOD OF SETTING LOCOMOTIVE SLIDE VALVES.

By Lieut. H. G. POTTLE, M.C., R.E.

THE writer of this article, having completed a railway course, mainly on the mechanical side, with one of the leading railway companies in the country, had many opportunities of studying the method adopted by this company for setting locomotive slide valves. Many readers will probably know the method about to be described, but it is hoped that there will be others who do not know it, or at any rate, some of its features. To the latter the following description may prove interesting and perhaps useful, especially as the method can easily be adapted for setting slide valves of stationary steam-engines.

For the sake of clearness and simplicity, the method of setting the valves of that very common type of locomotive—the twin inside cylindered, fitted with the ordinary "D" slide valves and Stephenson's link motion—will be described.

The method can be divided into five distinct operations :—

1. Finding the points of "cut-off" of the valves.
2. Finding the maximum port openings.
3. Recording the port openings.
4. Calculating and making the adjustments to equalize the port openings.
5. Trying over the valves to see if they are set correctly.

1.—FINDING THE POINTS OF "CUT-OFF" OF THE VALVES.

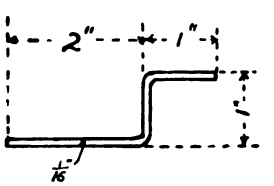

FIG. 1.

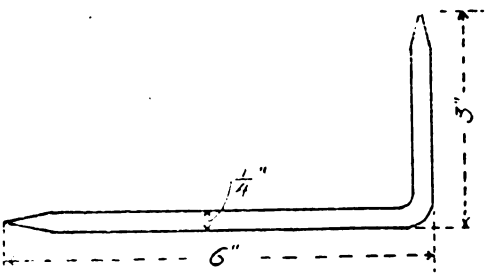

FIG. 2.

The "cut-off" points are found for each of the two valves separately, and to do this a piece of mild steel, about 3 in. long,

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1 in. wide and $\frac{1}{16}$ in. thick, is shaped as in *Fig.* 1. This is called a valve stop. A one-legged mild steel trammel, about 6 in. by 3 in., with sharp points, case-hardened for preference, is also made (see *Fig.* 2).

Taking each valve separately, the valve spindle is disconnected from the intermediate spindle, and the front steam chest cover is removed. The valve stop is inserted in the front steam port, and the front edge of the valve is rammed hard up against it as in *Fig.* 3. A centre pop mark is made in a convenient position on the back of the cylinder casting, and one point of the trammel inserted in it, while with the other point a mark is scratched on the spindle at A (see *Fig.* 3). A centre pop is then made on this mark. This gives the "cut-off" point for the front port.

The valve stop is released and inserted in the back steam port, and the back edge of the valve rammed hard up against it as in *Fig.* 4. The trammel is used as before, and the "cut-off" point for the back port is obtained at B (see *Fig.* 4). The distance between A and B ought to be twice the outside lap of the valve plus twice the thickness of the valve stop.

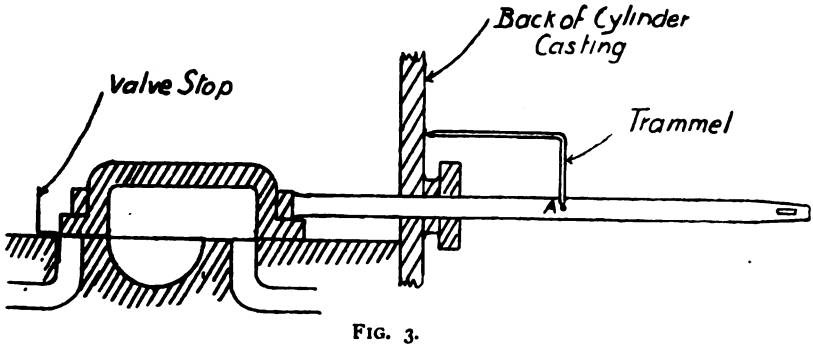

FIG. 3.

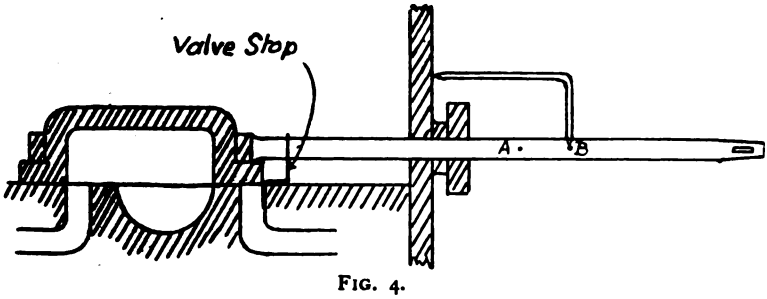

FIG. 4.

2.—FINDING THE MAXIMUM PORT OPENINGS.

Taking each valve in turn, the valve spindle is connected up to the intermediate spindle. The front steam chest cover can be replaced as no further work needs to be done inside the steam chest.

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The reversing lever is placed in the usual running position in fore-gear, say in the notch corresponding to a 50 per cent. cut-off. The engine is then slowly moved forward with the aid of pinch-bars used between the wheels and the rails. It is very desirable to do this over an ashpit, so that more room is available in which to work. A suitable position having been taken up inside the motion of the engine, the trammel is held in position as in *Figs.* 3 and 4, and as the pop mark at A on the valve spindle passes the point of the trammel on its *outward* journey, *i.e.*, *away* from the cylinder casting, scratches are made with the point of the trammel from side to side on the valve spindle, stopping when the spindle commences its return journey (see *Fig.* 5). A moment's thought will show that the distance from A to the last scratch at C (*Fig.* 5) gives the maximum opening of the front port.

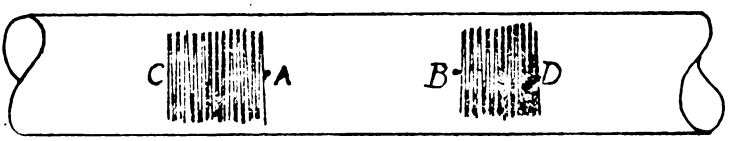

FIG. 5.

Attention is now transferred to the pop mark at B. As this point passes the point of the trammel on its *inward* journey, *i.e.*, towards the cylinder casting, scratches are made on the spindle as before, stopping when the spindle commences its return journey. The distance from B to the last scratch at D (*Fig.* 5) gives the maximum opening of the back port.

Actually the thickness of the valve stop should be added to get the correct port opening in each case, but as it is the *difference* between the front and back port openings that is required, the thickness of the valve stop need not be taken into consideration.

With practice, instead of finding the port openings for one valve and then repeating the operation for the other valve, the port openings for both valves can be found in one operation, thereby saving time and lessening the distance the engine has to be moved with the pinch-bars. From the position of the eccentrics, and from the fact that the engine has its right crank or left crank leading, it can be found which port will open first, and the order in which the other three ports will open. By transferring the trammel quickly from one valve spindle to the other, and back again, as the ports begin to open, the whole operation can be completed in just over one revolution of the driving wheel.

The reason why the reversing lever is placed in the usual running position—in this case it has been taken as the notch corresponding to a 50 per cent. cut-off—is that, in Stephenson's link motion, owing to the angularity of the eccentric rods, the front port opening

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becomes smaller than the back port opening as the lever approaches mid-gear and *vice versa*. Therefore it is advisable to make certain that the port openings are equal when the lever is in the position in which the engine does most of its work.

The maximum port openings of the four ports in fore-gear have now been obtained, and with a pair of fitter's spring dividers these are transferred to the plate shown in *Fig.* 6. This plate will be described in detail later.

The reversing lever is now placed in its running position in back gear, and the engine moved backwards. The scratches on the valve spindle are erased with emery paper, and the process of finding the maximum port openings is repeated. These four port openings in back gear are likewise transferred to the plate (*Fig.* 6).

3.—Recording the Port Openings.

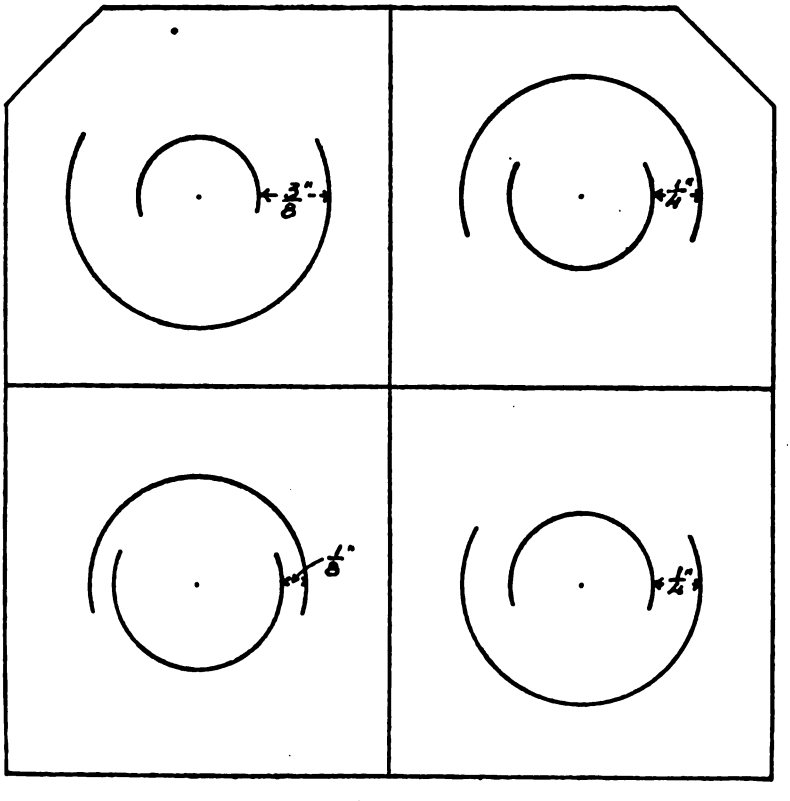

Fig. 6.

Fig. 6 shows a piece of tin plate, 4 in. × 4 in., with two of its corners cut off. The plate is divided into four parts, and a small centre pop mark made in the centre of each quarter. The port openings

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obtained on the valve spindle are transferred to this plate with a pair of dividers, by describing incomplete circles, the radii of which are equal to the port openings. In each quarter of the plate, the upper incomplete circle denotes the front port opening, and the lower incomplete circle the back port opening.

Now the top right hand quarter represents the port openings of the right valve in fore gear, the top left hand quarter the openings of the left valve in fore gear, and the two bottom quarters represent the port openings of their respective valves in back gear. Remembering this, it is quite an easy matter to transfer the respective port openings from the valve spindle to their correct positions on the plate. The corners of the top edge of the plate are cut off to denote that this edge represents the front end of the engine. The plate thus gives a complete representation of the maximum port openings of the two valves in both gears, and the difference between the openings can be measured from the plate itself.

4.—Calculating and Making the Adjustments to Equalize the Port Openings.

The plate in *Fig.* 6 is a representation of an actual plate obtained in practice. For the sake of clearness it will be as well to take each set of port openings separately to show how the adjustments are calculated and made.

The top right hand quarter, *i.e.*, the port openings of the right valve in fore gear shows the front part *larger* than the back by $\frac{1}{4}$ in. Therefore the right foregear eccentric rod must be *lengthened* by half this amount, *i.e.*, by $\frac{1}{8}$ in. This will have the effect of closing the front port by $\frac{1}{8}$ in. and opening the back port by the same amount, giving the two ports an equal opening of $\frac{1}{2}$ in., since the original measurements are $\frac{5}{8}$ in. and $\frac{3}{8}$ in. respectively (see *Figure*).

The bottom right hand quarter, *i.e.*, the port openings of the right valve in back gear, shows the front port *smaller* than the back by $\frac{1}{4}$ in. Therefore the right back gear eccentric rod must be *shortened* by $\frac{1}{8}$ in. This will have the effect of opening the front port by $\frac{1}{8}$ in. and closing the back port by the same amount.

The top left hand quarter, *i.e.*, the port openings of the left valve in fore gear, shows the front port smaller than the back by $\frac{3}{8}$ in. Therefore the left fore gear eccentric rod must be shortened by $\frac{3}{16}$ in.

The bottom left hand quarter, *i.e.*, the port openings of the left valve in back gear, shows the front port larger than the back by $\frac{1}{8}$ in. Therefore the left back gear eccentric rod must be lengthened by $\frac{1}{16}$ in.

The length of the eccentric rods are altered by handing them over to the blacksmith, who "draws them out" or "jumps them up" as the case may be, or metal liners of the requisite thickness are inserted or removed from the joint between the eccentric rod and

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strap. A point against the latter practice is that there is a possibility of the liners falling out when the engine is in service.

It must be mentioned here that with a new engine, which is having its valves set for the first time, an allowance is made, in calculating the adjustments, for the fact that the engine settles on its springs after a while. In an engine with inclined cylinders this settlement causes the valve to move forward in the steam-chest. To compensate for this the maximum front port opening is made $\frac{1}{16}$ in. larger than the back, so that when settlement has taken place the port openings are approximately equal. In an engine with horizontal cylinders the movement of the valve is in the opposite direction, so the front port is made $\frac{1}{16}$ in. smaller than the back.

5.—Trying over the Valves to See if They Are Correctly Set.

After the eccentric rods have been altered they are put up, and the process of finding and recording the maximum port openings is repeated. If the adjustments have been made correctly, it is found that the second plate shows the circles in each quarter practically coinciding. In the case of *Fig.* 6 they would all have a radius of $\frac{1}{2}$ in. showing that the maximum port openings have been equalized. A difference of $\frac{1}{32}$ in. or less is negligible. If the valves were very much out in the first instance, however, it is often found necessary to make a second series of adjustments, because a large alteration in the length of one eccentric rod would to a certain extent affect the other rod controlling the same valve. This series of adjustments is made in exactly the same manner, except, of course, that the "cut-off" points are already found, and it is therefore not necessary to remove the front steam-chest cover.

Setting Valves to Give Equal Lead.

To use the above method to set valves to give equal lead, the four dead centres are found in the usual manner by trammelling from engine frame to wheel rim and marking the slide-bar and crosshead. The engine is then placed on each dead centre in turn and the port opening in this position is marked on the valve spindle with the trammel as before. These port openings are, of course, the required leads. They are transferred to the plate and equalized in exactly the same manner as already described for equalizing the maximum port openings.

Opinions differ as to whether it is better to set valves to give equal maximum port openings or equal leads. The former method, which has been described in detail, and which was generally adopted by the railway company the writer was with, has the advantage that both ports give the maximum opening when the piston is moving at its maximum speed, and the admission of steam does not tend to be

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strangled at one end. Also the method is much quicker, as the dead centres have not to be found, and in a locomotive running shed, where time is a valuable factor, this is an important consideration. On the other hand, if it is found that there is very unequal compression at each end of the piston stroke, the valves have to be set to give equal lead, and the equality of the port openings has often to be sacrificed to enable this to be done.

In conclusion, the writer considers that the method described above is better than the method of finding the port openings by direct measurement or by the insertion of wedges. Owing to the restricted space in the average steam-chest, the back port is not very accessible. While there is usually enough room to get a hand in and insert the valve stop shown in *Fig.* 1, there is not enough room to hammer in a wedge or to take a direct measurement, and in consequence the port openings cannot be measured so accurately. Also by the use of a plate, as in *Fig.* 6, the state of the valves can be seen at a glance, and much more easily than they could be if the readings were tabulated on paper. The method necessitates a somewhat long and detailed description, but in actual practice it proves to be quite simple and gives very satisfactory results.

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THE NEW MAP OF EUROPE.

A lecture delivered at the S.M.E., Chatham, on 16th November, 1922, by FRANK J. ADKINS, M.A. *Camb.*

SINCE frontiers enter so largely into this subject, a few words about frontiers in the abstract are, perhaps, worth while by way of introduction.

Good frontiers provide actual barriers, or No Man's Lands, between states, *e.g.*, the sea, a mountain water-shed, marshes. Bad frontiers, on the other hand, are those purely arbitrary and ever-shifting lines traced by successive peace treaties (the straight-lined frontiers one sees so often in the New World have as their original an old line drawn by the Pope between Spanish and Portuguese Brazil). A river-line is not a good frontier. Bridgeheads are required beyond it; and, moreover, it divides an area which has been united by Nature: namely, the basin drained by the river. The redrawing of frontiers always intensifies the difficulties of irredentism of the minority left on the wrong side of the frontier, and trying to rejoin the majority. No frontier can be so drawn as to make clear divisions. If a process of exchange of holdings and sorting out on both sides of a given frontier can be organized, greater stability is likely to result. Lastly, frontiers which cut up economic units and separate mutually dependent and complementary areas are obviously sources of future trouble.

Turning from the unsatisfactory fringes of States, let us now consider the nature of the growing principle by which States have been formed from their original nuclei. The habitable land of a temperate area like Europe is of two kinds: either the low-lying and originally tree-covered valley of a river, or else the grass-covered uplands of the watersheds and plateaux. These two sorts of land attract two types of man. The valley forests are gradually cleared by the settlers; the upland grass-lands are the grazing grounds of the nomads. The settlers, in the course of generations, clear the forests to the watershed and, following the river course, reach the sea at its mouth—as the Poles did along the course of the Vistula long before the Brandenburgers conquered Prussia. The settlers are the builders-up of Nationality based on agriculture and held together by a common language and customary law. We might imagine, therefore, that national areas, undisturbed and developing under ideal conditions, would coincide with river basins, and national boundaries follow watersheds. But such undisturbed development is never found. The lowland settlers are frequently raided by the more vigorous of the nomadic peoples, whose incursions, though destructive for the moment, are also, in the long run, stimulative to the slower-

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moving settler type. Where fusion of the two has taken place, a more energetic race has, as a rule, resulted. But frequently such fusion has not occurred and thus we find, in most parts of Central and Eastern Europe, two distinct types intermingled: the settler agricultural peasant, and the ruling class descended from the original nomads; and in particular from those blue-eyed, light-haired Nordic nomads of Scandinavian type who play so large a part in the history of Europe. Lastly, in so far as a middle class of traders and professional men exists in these parts of Europe, such a class is supplied from a third source: the alien or Jew. The fusion of these contrasted types is a difficult business; and nationality, as we know it in Western Europe where definitely French, English, Dutch, Swiss, Belgian, Spanish nations are to be found—even in spite of mixture of languages as, *e.g.*, in Belgium and Switzerland—becomes progressively more hard to determine as we move eastwards across Europe

I propose, therefore, to leave out of account the whole of West Europe. Such changes as the French recovery of Alsace-Lorraine belong to another category from the changes in Central and Eastern Europe and I do not propose to plunge into the Empire of Charlemagne and the Partition of Verdun to trace the varying fortunes of that No Man's land between France and Germany—Lothai's Kingdom, Lothringen or Lorraine—which becomes one of the chief battle lines of the Continent.

On the East my subject is also limited. Europe is really one of the peninsulas of the great mass of Asia; and Europe of the Sea may justly be regarded as springing from the Continental mass along the line which now forms the Western boundary of Russia. Russia is now geographically Asiatic: perhaps, also, its outlook tends to become increasingly Asiatic. At any rate, I exclude Russia from this lecture.

In studying the remainder we have first to note the influence of the two great inland seas, the Baltic and the Mediterranean, on the land mass. The Finnish movement southward gives us that fringe of non-Slav peoples along the Eastern Baltic which has crystallized into the new states of Esthonia, Latvia, Lithuania; while the earliest rule in Russia was that of the Swedish house of Rurik which at one time extended as far south as Kieff: a notable example of Nordic domination of the Slav.

The Mediterranean influence has been more profound. Rome and Constantinople, capitals of the Western and Eastern Empires, became the civilizing centres whose influence, chiefly religious, spreads throughout the Continent. Even Protestant Europe is only Reformed Roman: while the Russian Church is but a branch of the Orthodox Church which still centres in the Patriarch of Constantinople. In between the two Churches, occupying the Ukraine (Ruthenia) and Transylvania, we find the Uniate Church, Orthodox in form but acknowledging the Pope. Further, to Rome we owe

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those conceptions of Law and Union which express themselves later as the Holy Roman Empire, International Law, etc. The Pax Romana may be compared with the League of Nations; and W. T. Stead used to advocate the re-establishment of the arbitration powers of the Pope. Lastly, Roumania is in a sense Roman: ancient Dacia, with a language moulded on Latin lines.

We can now turn to that portion of Europe which lies between Russia and the Rhine, and across this area I wish to draw yet another line: a line running due North from Venice. I wish, for the purposes of this lecture, to regard this line as marking the Westward limit of the Slavs, for it is about the Slavs that I am chiefly concerned this evening. Whether the words Slav and Slave are connected or not, the Great War may be regarded essentially in its results as the freeing of the Slav and the re-establishment of those ancient States which existed in Europe before the empires based on Teutonic or Turkish domination were built up out of them. If, then, we can imagine the Slav as spreading originally over the whole of Europe east of this line, we have the basis we need. But, as I have said already, this basic mass of peasants is subject to penetrations, and it is these penetrations that we now have to trace.

The first is the Teutonic penetration which, in the guise of a Crusade, led the Teutonic knights of Brandenburg under their Hohenzollern leaders along the Baltic. From the younger sons of these Baltic barons, essentially German although Russian subjects, the pre-war Russian bureaucracy was largely recruited. Russia was thus largely a Slav body with a German head. The other Teutonic penetration took the form of an advance along the Danube to the point where it enters the Great Plain of its basin, *i.e.*, to Vienna, which becomes the bulwark of Christendom against the Turk after he had overwhelmed the ancient bulwark of Constantinople in 1453. As the Turk was pushed back Austria grew by the absorption of the reclaimed lands until it became the great composite Empire we knew before the War. With its Magyar extension and the Latinized Roumanians to continue the line to the Black Sea we have a non-Slav band stretching right across the centre of the Slav area and dividing Slavdom into two portions: the Northern (Russians, Poles, Czechs, etc.), and the Southern (the Serbs, Bulgars and others of the Balkans). Perhaps the most striking point to note about the New Map is to see what has happened to this dividing band of non-Slav states (the Magyars are more of the Turanian or Mongol type than white). It is still there, but so thin and shrunken that (with the exception of Roumania, which has, of course, swollen out enormously at the Eastern end of the band by absorbing Transylvania from Hungary and Bessarabia from Russia) at one time Hungary, at any rate, seemed to be in danger of being pinched out altogether. The new states of Poland and Czecho-Slovakia on

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the North and of Yugo-Slavia on the South have been constituted by the break-up of the Empire which originally represented the reward and result of the Austrian championship of the Cross against the Crescent.

The second penetration is from the South-East and has already been referred to more than once: it is the Turkish penetration from Asia which began in the middle of the 14th century but made its greatest headway after the fall of Constantinople in 1453. (It should be noted, of course, that Constantinople had been Christian for a thousand years before it became Mohammedan; and that to-day it is still a great Greek Christian centre.) The Turkish advance into Europe continued until it was checked before Vienna by John Sobieski, King of Poland, about 250 years ago; but from that high-water mark the Turks have been receding ever since, as a study of any historical atlas will show. We cannot, however, pursue the consequences of this penetration for the moment. We must leave it until we have dealt with the Northern Slav States, Poland and Czecho-Slovakia.

There was a great Moravian Empire stretching indefinitely into Russia in the ninth century. Bohemia was a Duchy before Vienna appeared on the map. The University of Prague is the oldest north of the Alps. The Prince of Wales' Feathers were originally the crest of the King of Bohemia killed at Creçy, 1347. John Huss is the connecting link between our Reformer Wyclif and the German Reformer Luther. The Winter Queen, whose expulsion from Bohemia led to the Thirty Years' War which reduced Germany to savagery, was a sister of Charles I. The Bohemians should have had a position within the Austrian Empire at least equal to that of Hungary, but the old Emperor Francis Joseph always refused to go to Prague to be crowned. The new President Masaryk was a Professor of London University in the days of his exile. The new State has great resources, but is landlocked. The internationalization of the Elbe, the Oder and the Danube give her some sort of access to the sea, at any rate in peace time; and Pressburg is becoming an important Czech Danube port. Moreover, at Hamburg and Trieste the Czechs have customs-free areas. Nevertheless, the tradition of Vienna is still strong enough to draw and retain much of the business and banking of the new State—and still more of South-East Europe. (If anything could be done to save Vienna from sinking to the size of a capital of a few million Austrian-Germans, Europe would be the gainer. Its central position has suggested to some that it might make a good seat for the League of Nations.)

The New Poland is in a less assured position. Three hundred and fifty years ago Poland reached almost to Moscow and Odessa. We have seen what Europe owed to the Poles under Sobieski. But Poland, although able to save Europe, could not save herself. As a result of three partitions she was absorbed by her neighbours, Prussia, Austria and Russia. Napoleon, however, reconstituted her

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for a moment in connection with his Moscow campaign as the Grand Duchy of Warsaw. French support of the new state is thus on historical lines. Nevertheless, if Poland is to play the part assigned her of a State to keep apart those two complementary States, Germany and Russia, she will need very exceptional political qualities ; and the story of her past hardly suggests that she possesses them. Moreover, in pre-war days the ally of France was not Poland, but Russia ; and if ever the unofficial feelers between France and Russia now to be observed should become more definite, possibly French interest in Poland would take a somewhat different form.

We turn now to the Southern Slavs of the Balkans, who had been overrun by the Turks and kept marking time for centuries. The Turk, unprogressive himself, had no use for progress among his subject peoples, who, nevertheless, managed to retain their Faith and their sense of Nationality. The primitiveness of Turkish political ideas may be judged from the fact that only in this year (1922) have they ventured to separate the Temporal and Spiritual powers of the Caliph. Their rule is a militant theocracy and therefore unlikely to meet the needs of other races and creeds and the complexities of modern conditions. The rate at which they lost their huge Empire, stretching, as it did originally, from Vienna to the Persian Gulf and from the Caspian to the Red Sea, is an indication of their political and administrative limitations.

The Greeks, helped by Lord Byron, were the first to shake themselves free about a century ago. But the Slav peoples did not agitate effectively till after the Crimean War. In the twenty years, however, which separate that war from the " Jingo " war between Russia and Turkey, Russia was encouraging her younger sisters of the Balkans against the common enemy ; and the Treaty of Berlin in 1878 redrew the Map of the Balkans so as to leave Turkey merely the strip from the Adriatic through Albania to the Bosphorus with which we were all familiar in our school days. But the shrinkage of Turkey continued in the twentieth century also. The Revolution of 1908 lost her not only the Suzerainty of Bulgaria (Prince Ferdinand becoming a King and " Czar of the Balkans "), but also the provinces of Bosnia and Herzegovina which had been handed to Austria to administer, but not to possess, by the Treaty of Berlin in 1878. In 1908, however, 30 years afterwards, Austria seized them and thus took a step which, as we shall see directly, led to the Great War.

But the troubles of Turkey did not end with these losses. A year or two later she found herself at war with Italy over Tripoli, and this war so exhausted her that she had no strength left for the new danger which threatened in 1912. Venizelos had managed to bring all the neighbours of Turkey together into the Balkan League ; and these Allies smote Turkey on every front with such effect that she crumpled up and retired to the Chatalja lines. But the unity which

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had secured this triumph broke down under the strain of dividing the spoil. Bulgaria, who had done most of the fighting and secured an Ægean outlet as a reward, wished for a Westward extension towards the Adriatic also; and thus came into conflict with Serbia over the Monastir area; while, as regards Greece, Bulgaria wanted Kavalla. Thus arose the second Balkan war of 1913, in which Bulgaria suffered defeat in the West. The Turks, moreover, seized the opportunity of Bulgarian weakness to push their frontier back again to Adrianople, while even Roumania seized the same opportunity for pushing her Dobrudja frontier further South. Thus was the backwardness of the Balkan States, due as it was to centuries of stagnation and arrested development under Turkish rule, emphasized.

I have already spoken of the seizure of Bosnia and Herzegovina by Austria in 1908 as important: as leading, indeed, to the Great War. In the eighth century Serbia extended along the whole of the Adriatic shores westward to a line which took her west of Istria and back northward to the Drave. Thus originally the two provinces which had gone in 1908 to Austria were part of Serbia and remained so at any rate till the middle of the twelfth century. The Serbs had always expected to recover possession of these provinces on the break-up of Turkey, and when they found them seized by Austria they determined to prevent them from settling down as Austrian provinces. To deal with the Irredentist Movement thus started Austrian Army manœuvres were organized, and in connection with these the Austrian heir, the Archduke Ferdinand, paid that visit to Sarajevo which ended in his assassination on June 28th, 1914.

The establishment of Yugo-Slavia as the greatest of the Balkan States with a long coastline on the Adriatic has caused some anxiety in Italy, who has, of course, inherited the Adriatic traditions and position of Venice. The Doge was Duke of Dalmatia. Venetian factories and trading stations like "Zara Italianissima" dotted the whole of the Balkan coast as European stations to-day dot the coast of Africa. When, therefore, the Slavs of the hinterland awoke to national consciousness they found all their ports and openings in Venetian hands. The story of D'Annnunzio and Fiume is thus, in a sense, a throw-back to a picturesquely medieval period. But Italy is wiser than her warrior poet and has agreed to arrangements on the opposite coast which give to the new State all the openings she needs. Zara alone remains under Italian protection; also the island of Lagosta, while one of the two Channels between the islands to Fiume is mainly Italian. Nevertheless, the contrast between the two coasts of the Adriatic is still striking and we can understand Italian anxieties as to the possibility of developments among peoples so newly freed and in consequence so relatively undeveloped as the new States which face her across the Adriatic.

For a handy geographical study of the peace terms, readers are referred to "Aftermath," by Marian I. Newbigen, D.Sc. Macmillan (3/6).—EDITOR, *R.E.J.*

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NOTES ON RAILWAY WORK IN EAST AFRICA, 1914–1918.

By CAPTAIN H. L. WOODHOUSE, M.C., R.E.

THE provision of railway troops for the Indian Army was taken in hand as a result of the experience gained during the China War of 1900. Two companies of Railway Sappers and Miners were raised in 1903 and 1906, and the East African Expedition of 1914 was the first time that these companies were used in the field. In comparison with the other campaigns of the Great War this was a small side-show; however, at one time there were 80,000 British troops in the country, 40,000 of whom were white, and about 400,000 native carriers; and in 1917 the bloodiest battle ever fought by British troops in Africa, not excluding the actions of the South African War, took place. In one respect the campaign was of especial interest, as its conditions bore considerable resemblance to those of the small wars which have been so frequent during the last hundred years. The opposing forces were moderate in number, distances were great, means of communication bad, and climate most trying. Except for the Uganda Railway, and the two railways of German East Africa, tansportation in pre-war days was usually by porter. Animal transport was unreliable owing to the ravages of tsetse fly over large areas, and the prevalence of East Coast fever; navigable inland waters were few; and roads hardly existed, thus much increasing the difficulties of motor transport; so that railways and tramways took a large part in the transportation arrangements.

The Railway Detachment which formed part of I.E.F.B. was built up on the two companies of Railway Sappers and Miners, and the Loco and Traffic reserve attached to them. It also included a Labour Corps raised from the relatives of the Sappers, from whom the most promising men were afterwards enlisted into the companies, and a number of artisans drawn from the Indian State Railways, who formed the workshop staff. In addition to the eight R.E. officers with the companies, six Indian State Railway officers formed part of the original force, and as the campaign progressed, additional railway officers from India and South Africa arrived, while the care of the large bodies of African labour employed was entrusted to East African residents.

I.E.F.B. landed at Mombasa in November, 1914, The 25th and 26th Companies were almost immediately distributed over the

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Uganda Railway as bridge guards, but six weeks later they concentrated, and after being fitted out with ox transport were employed on the road from Kajiado to Longido, and on the posts on Longido mountain. Early in March, 1915, they rejoined the rest of the Railway detachment at Voi, a station on the U.R. about 100 miles from the coast, and started railway work.

This work fell into three parts. The first, which took from March 1915, to April, 1916, was the construction of a line from Voi to Moshi, the terminus of the German line from the port of Tanga to Kilimanjaro, and the improvement of the U.R. by the addition of a number of crossing stations. The second comprised the repair of the damaged German railways and the construction of two short branch lines. This took from May, 1916, to June, 1917, during which time the whole of the Northern Railway and some 500 miles of the Central Railway were made fit for traffic, and a good deal of work done on the harbour wharves at Dar-es-Salam. The third period, from June, 1917, till the German forces were driven out of German East Africa, was spent on laying 60-centimetre lines from the southern ports of Kilwa and Lindi inland, and in wharf building at Lindi.

Owing to military considerations the Voi-Moshi line was laid in three parts. The first 38 miles to Maktau was constructed in March–June, 1915, the next 20 miles to Njoro in January and February, 1916, and the final 37 miles in March and April, 1916. The main engineering difficulties were the lack of water and the shortage of plant. The standard metre gauge common to both British and German lines in East Africa was naturally adopted. It turned out to be very suitable, as it struck the happy mean of reasonable capacity without unduly ponderous material, the latter of no small importance when it is remembered that all material, with few exceptions, had to be brought from overseas. The ruling grade was 3 per cent. as compared to the U.R. 2 per cent. In one instance this was departed from, as a choice between very sharp curves on the maximum grade, or very heavy earthwork, was settled by laying a straight line on a 4 per cent. grade. This was of less importance as the heavy traffic ran down the grade, and only lightly-loaded trains had to pull up the slope. A 4 per cent. grade was also adopted for a velocity dip in which the momentum gained by running down one side helped the train up the other. At first this was rather a stumbling-block to the drivers, but after a train which had tried to take it too slowly had stuck at the bottom, they learnt to rush it.

Earthwork was done by African labour, after the survey had been made by a special survey gang from India. For the first 30 miles the bush was very thick, which added enormously to the difficulties of choosing a good location. A surface line was aimed at, and heavy banks or cuttings were few.

Platelaying, bridge erection, station buildings and water supply

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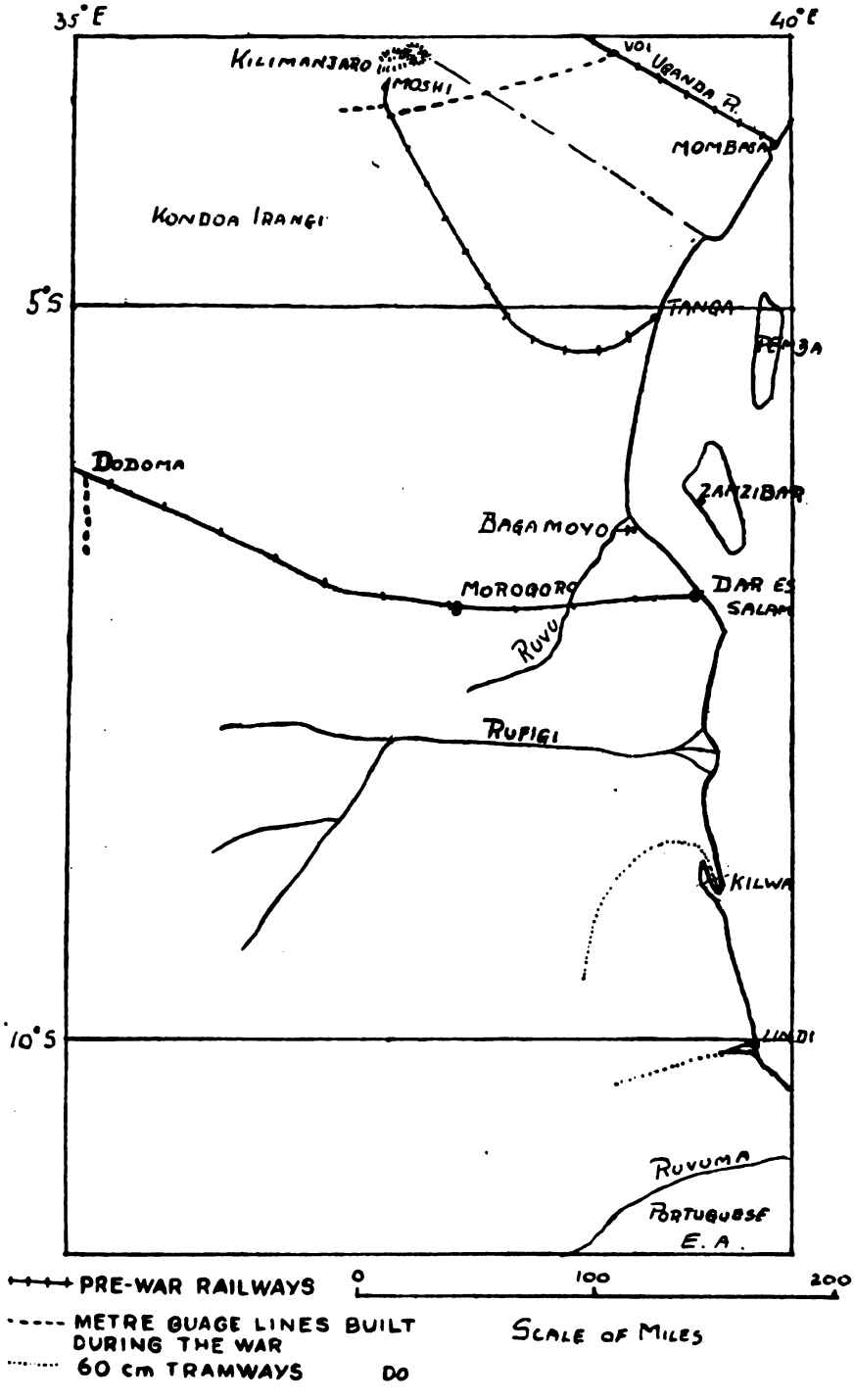
SKETCH MAP OF EAST AFRICA.



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were undertaken by the Sappers with some attached African labour. The chief difficulty in the platelaying was the great variety of material used. Not only had the detail of work to be altered frequently, but a careful watch was necessary to ensure that train-loads were made up of the same pattern of material. Four types of sleeper and as many types of rail were used in the first 38 miles. Progress was limited by the supply of material. The old engines in use, at first, found half a mile of track quite as much as they could manage over the steep grades. Later, when better loco power was available it was found that for continuous work a mile a day for a company of about 165 working strength and with 150 Africans to carry sleepers, was most economical. If this rate were exceeded the output of energy per man per day exceeded his recuperative powers by night, and the sick list went up considerably. If speed were of great importance two shifts were worked, each company taking one shift, but the normal procedure was for the companies to platelay on alternate days and spend the other day packing the work just done. All wooden sleepers were bored before reaching railhead, and in view of the difference in breadth across the foot of the various patterns of rail, the spacing of the holes had to be altered to suit the rails for which they were intended. A gang of coolies 50 strong was kept continuously employed on this job, and the consumption of augers was considerable. Both dog-spikes and coach screws were used with the wooden sleepers. The latter made a rather better job provided that a watch was kept that they were not hammered home instead of being screwed in, but they were a little more trouble to fix. If there were sufficient men available to double the number of spikers, the falling off in speed of linking due to the use of screws instead of spikes was not great.

In the 95 miles there were only eight bridges with spans of 40 ft. or more. This gives some idea of the dryness of the country. Spans of plate girders of 20-ft. or 40-ft. clear span were brought up by rail, already cross-braced. The piers were 12 in. × 12 in. piles or trestles. Pile-driving was done by hand. The girders were launched on well-greased rails, which were removed after the girders had been lifted clear of them on jacks. Some 85-lb. rails were found very useful for this job. In two instances the bridges exceeded 100 ft. in length, but there was nothing unusual about any of them. The streams over which they were thrown were in ordinary times insignificant, but were liable to sudden floods which severely tested the work done.

Culverts were made of corrugated iron pipes. These were easily carried forward by the earthwork parties, and put into position by the officers in charge of the earthwork party before starting work. The first lot of pipes were bought, but later a set of wooden rollers was put together in the base workshop which made quite good pipes,

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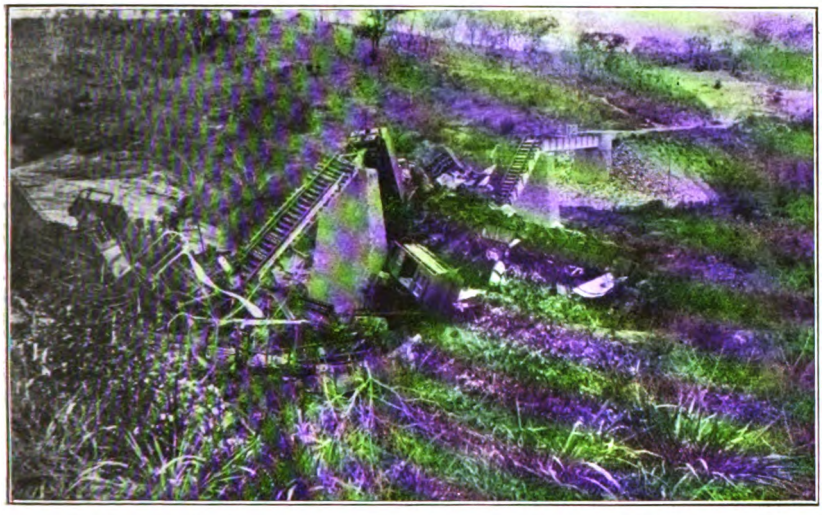
NOTES ON RAILWAY WORK IN EAST AFRICA.



Bridge on Central Railway G.E.A. Demolished by the Enemy.

Voi—Moshi Railway in course of construction.

The photographs were taken by Lieut.-Colonel L. N. Malan, O.B.E., *R.E*

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and by their use a considerable saving was effected. A plentiful supply of culverts was found to be the truest economy, as, in several doubtful cases where they had not been installed, the result was a wash-out sooner or later.

Where there were streams, water was supplied for the engines by A-frame hand pumps, pumping into 4 ft. × 4 ft. × 4 ft. or 8 ft. × 8 ft. × 4 ft. tanks on Sullivan staging. This is a portable form of scaffolding made of piping and rods which can be erected easily to any reasonable height. The hand pumps were replaced by steam pumps later on. From miles 20 to 74 there was no natural supply, and recourse was had to a pipe-line laid to miles 32 and 38 for the supply of the troops. All engines had an extra water-tank behind the tender, which reduced the useful load they could pull.

Station buildings were the grass huts of the country. Tarpaulins were added to make them water-tight during the rains. In some cases they were within the perimeter of fortified camps, in other cases small blockhouses were built round them.

Train working was by telephone, under the direction of a central control station.

The repair shops at Voi gradually increased in size as more engines and tools arrived. The chief difficulty confronting the loco officers was, however, the fuel supply. Wood was used at first, as was the U.R. practice, but time had to be allowed for the newly-cut wood to dry, so requirements had to be foreseen some time ahead. As traffic increased, it became more and more difficult to allow time for the fuel trains to pick up loads from the stacks along the line. The difficulty became so great that in the end coal replaced wood as the fuel.

Up to the time of the main advance in 1916 the enemy made constant attacks on the line. His usual method was to lay contact mines, which rendered it necessary to run bomb-crushing sand trucks in front of all engines. Night running was prohibited and the line patrolled daily before the first train ran. Between sleepers the earth ballast was kept 2 in. or more below the bottom of the rails, and on several occasions bombs were discovered and removed owing to the disturbance of this arrangement. By day sentries were posted to watch each straight, and a patrol arranged to inspect the whole line at intervals so short that enough time was not allowed for laying a bomb in position. No serious attempt was ever made to interfere with the working parties, though at one time the line was being built five miles in front of the outpost line.

The time of greatest pressure on the Traffic department was during the concentration of the South Africans around Maktau in January, 1916, but the most critical time was in April of that year. General Smuts had driven the enemy out of the Kilimanjaro area just before the rains began, and it became imperative to get the railway

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through, as the roads became practically impassable during the rains. The line was open to Moshi four days only before supplies would have run out. In one place the line went through a flat which the rains turned into a swamp. The sleepers floated and had to be held in place till the rails were laid on them. After the first train had passed, the whole line disappeared beneath the mud, and soon the rails were as much as 6 in. out of level. The sight of a train creeping through what appeared to be a sea of mud, with every vehicle tilted to a different angle was one not easily forgotten. The construction train was naturally frequently derailed; usually, after safely passing apparently impossible places, waggons would come off for a trifling cause. The task could not have been accomplished in time had it not been for the whole-hearted efforts of the sappers.

During the intervals of railway construction extra stations were laid on the U.R. and some road-making and fortification work was carried out at Maktau, which led to several skirmishes.

The second phase began in May, 1916. The enemy had destroyed stretches of line amounting to about 20 miles in all, and had blown up all the bridges on the line from Kilimanjaro to Tanga. This line was found to be about three-eighths of an inch narrower gauge than the U.R. metre gauge, but beyond some squeaking on curves which wore out wheels rather quickly, there was no trouble in running our own rolling stock on the line. The first train had some difficulty in getting up the steep slope from the outposts on the day the advance began, owing to an unusual cause. The line was intact, but had not been used for some weeks, and the grass had sprouted to a height of about six inches. As the leading wheels crushed it down the juices spread on the rails, which became so slippery that the engine could get no grip and slipped furiously. It was not until an advance party had cleared the grass away that the train could cover the first mile or two. Where the track had been destroyed the rails had been left lying in the side ditch, but the sleepers had been removed in places and used for bridge cribs, dug-out roofs and other purposes. They were easily recovered, but the smaller stores, such as fish-plates, fish-bolts, and sleeper-clips, were not so easily found. After some progress had been made it was found to be simpler to relay with new material. The various expedients tried, such as clipping every third sleeper, resting the ends of the rails on wooden blocks and fastening them there with coach-screws, were very slow and did not give a good enough track. Various methods of bridge repair were adopted. Rail girders on cribs built of German sleepers and filled with ballast were common, but had to be replaced after a time as the steel sleepers gradually flattened out. The first of the three 50-metre spans met with was repaired in a morning, as the demolition had been poorly executed; the two

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others, which were over the Pangani river, were replaced by temporary trestle bridges with girders of 85-lb. rails.

While occupied on this work the 25th and 26th Companies, with some details (the whole under the command of Lieut.-Colonel Wilkinson, then Commandant of the Railway Sappers), had to drive off a party of enemy some 600 strong, who were attempting to interfere with the line of communications.

The enemy rolling stock was found on the last 30 miles of the line. In some places trains were found wrecked on the running line, but the positions for these obstacles had not been well chosen and diversions were quickly made, pending their removal. The telegraph instruments had all been removed or destroyed and the engine watering arrangements damaged, but repairs were carried out as fast as the line was put into running order. The country was much better watered than was the stretch across which the Voi-Moshi line had been built. The points and crossings had, in most cases, been destroyed or removed. In some cases the missing parts were recovered, in others British material was installed. The amount of smith's work required in the manufacture of junction fish-plates to join British and German rails was very considerable. A strong party of coolies with civilian bridge erectors followed the companies down the line and strengthened the hasty repairs where necessary.

The 27th and 28th Companies had joined the force in April and May. The latter assisted in repairing the Tanga line, the former built a short branch from near Moshi to improve communications with the detachment at Kondoa Irangi. This line required several fair-sized bridges to be built, but was never much used.

After a short halt at Tanga the companies moved by sea to begin work on the Central Railway. The main army had cut this line at Morogoro, 100 miles, and Dodoma, 250 miles from the coast, and temporary repairs had been made by the South African Pioneers between, and for some distance on either side of, these places. These repairs were enough to allow of 30-cwt. lorries mounted on railway wheels carrying supplies to the columns on the flanks. Two companies landed at Dar-es-Salam, and the other two at Bagamoyo, whence they marched across country to start work at once on the repair of the large bridge over the Ruvu river, which had been completely destroyed. The efforts of the whole battalion resulted in the line being repaired as far as Tabora (500 miles inland) in two months, or one-third of the time which the enemy had allowed for the work. Fortunately, no damage had been done to the track, so the companies advanced in leapfrog fashion from one bridge to another, carrying their baggage first on trollies hand-propelled, later by motor lorry. This could hardly have been done if the enemy had destroyed the track as he had done on the Tanga line.

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From the coast to Morogoro the line ran through rough country entailing a large number of bridges, and it was here that the principal damage had been done. However, an oversight on the part of the enemy assisted the work considerably. Just before the war some five or six miles had been reconstructed. The rails and bridges on the old line were practically intact, so a little work enabled this stretch to be taken into use again in place of the new line, on which a number of fair-sized bridges had been thoroughly destroyed. A very useful find was a number of 20-ton differential blocks. With these and a derrick quite a number of 10-metre plate girders which had been blown off their abutments, but were otherwise little damaged, were rapidly replaced either on the repaired abutments or on trestles.

When the temporary repairs had been finished more substantial work was put in hand, including rebuilding damaged abutments in masonry, re-erecting German water-tanks, and combining the undamaged parts of bridges to form new spans. In March, 1917, three companies began work on a new branch southwards from Dodoma, but by the time this was ready changes in the situation had made it unnecessary. The fourth company was meantime employed on the construction of wharves at Dar-es-Salam, and the installation of steam cranes.

It was at about the end of the time spent on the Central Railway that the effects of the climate began to grow serious. During the work on the Voi-Moshi line the sick rate had been very low, lower, in fact, than that of the infantry, a result which was probably due to the steady work during the long period during which the Army was stationary, awaiting the arrival of the South African reinforcements. The climate was not at all bad for the tropics, and the physical standard of the men good.

The expansion of the companies and the drain on India for recruits of all sorts had lowered the physical standard considerably by the middle of 1916, and the prolonged work in the very unhealthy coastal region of the Central Railway sapped the health of all ranks. The companies employed on the Dodoma branch, which was several thousand feet above the sea, recovered, to some extent, but the company employed at Dar-es-Salam during that time had become decidedly the worse for wear by June, 1917.

The third phase opened in June, 1917. The enemy had retreated southwards from the positions he had held for some time on the Rufiji river, about 50 miles south of the Central Railway; and the line of supply for the main body of our troops was changed to the Port of Kilwa, on which part of the Army had been based for some time. A 60-cm. tramway to supply this force had been started by a party of coolies, and two companies were sent to take over and hasten its advance. Another company was sent to Lindi, a port

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near the Portuguese frontier, which had been occupied by a detachment some time previously. A pre-war 60-cm. line ran inland for 13 miles to some large plantations, but the inland terminus was, in June, still in the hands of the enemy. A few months later the main base was transferred from Kilwa to Lindi, and this line and its extension became the line of supply for the greater part of the Army. The two companies on the Kilwa line were brought round by sea to help on the Lindi tramway, and half of the company which had been left on the Central Railway was set to work to build more wharves at Lindi.

The track for the lines from Kilwa and Lindi was obtained from the plantation lines which had been built on many of the large estates. Ford cars were mounted on tramway wheels and used both to carry loads and to drag trailers. The latter were made up from the bogie waggons found on the plantations, altered by the substitution of much lighter wooden bodies for their heavy iron bodies. These were quite satisfactory and had the advantage that in case of a serious breakdown they could be lifted clear of the track by a few men. The drivers were from South Africa and India and were very short of training. In most cases they had no idea of putting right the smallest fault in the engines, so the tractors were run in convoys of about a dozen at a time and a mechanic travelled on the rearmost vehicle. Every time a stoppage occurred the whole convoy behind the lame duck stopped till the mechanic came up to put matters right. His job was no bed of roses. In addition to mechanical breakdowns one set of tractors reached the force with a bad fault in design, which resulted in every one of the lot being out of action with a broken back axle in a few days. The junction between the axle and the stub of reduced diameter on which the wheel was carried had been made square and not rounded off. It seems a trifle, yet the results were most serious. Shops were built at the sea terminus to execute repairs, but there was a shortage of mechanics and cars failed much faster than they could be repaired. Two small steam engines were tried, but they shook the light track about to such an extent that their use had to be stopped almost at once.

The extension of this line when the advance began was a difficult problem. The capacity of the line was already being taxed by the forwarding of supplies, and the provision of tractors to take forward track was very difficult. Matters became critical during the time which elapsed between the arrival of the main body on the Lindi line, and the arrival of the Kilwa companies and tractors. The unhealthy climate, too, was having serious effects. On men already below par, its results were disastrous. One company which landed at Lindi in June, 1917, with a working strength of about 150, could with difficulty muster more than 35 men for work in January, 1918.

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Of the three Indian officers and 40 other ranks who had formed part of the original company and were still with it in June, 1917, two Indian Officers and ten other ranks died during the following six months.

By this time, however, the railway work of the campaign had been almost finished. The enemy retreated into Portuguese territory at the end of November, 1917, and from then onwards was pursued hither and thither in such a way that there was never time to do much towards improving any particular line of communication before it had become of minor importance. In these circumstances one company returned to India in February, 1918, two more in April, and the last, weeded of its weakest men and strengthened by those from the other companies who were the latest arrivals, remained till September before following the other three.

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THE ENGINEERS OF AN ARMY CORPS IN FRANCE.

By MAJOR W. HYDE KELLY, D.S.O., R.E.

IN the original Expeditionary Force of 1914, the only Engineer establishment laid down for an Army Corps (or Army, as it was then called) was one Chief Engineer (a colonel) and one clerk. No particular units were told off as Corps Engineers, although one or more Fortress Companies might be available as Army Troops. The Chief Engineer was, as War Establishments expressly stated, a " technical adviser in Engineer matters " without any executive powers. This anomalous situation, of course, was rapidly altered at the outset of the campaign.

At first, the Chief Engineer had to detail what R.E. labour he could borrow from divisional engineers. Two fortress companies, the 20th and 42nd, were early on the scene, and the two bridging trains acted to some extent as Army Troops, and furnished officers for supervision of working parties.

Up to the time when the Armies came to a halt on the Aisne (September 12th, 1914), practically all the engineer work had been confined to the divisional engineers, but with the consolidation of the positions on the Aisne, it became necessary to start work on Corps defence lines. The only labour available for this work was that of battalions in reserve, and with the continual attacks and alarms these battalions got very little rest and were continually changing. There were no civilians in the neighbourhood, all had fled on the first invasion, and although the villages had not yet been much damaged, they were empty. The farmhouses were searched for tools, and a large number of the long-handled French shovels were collected for the working parties. Fire trenches were dug more or less extensively on the high ground south of the Aisne, and mostly among the sugar-beet fields. Not much could be done, however, owing to the heavy calls on the troops in the front line.

When the Army moved northward into the Ypres-Armentières region, a large number of Belgian and French refugees were still pouring westward, and from these fairly large working parties were formed under R.E. officers.

The 20th and 42nd Fortress Companies (later called Army Troops Companies) became virtually Field Companies, and were distributed as far as possible, with civilian digging parties. Behind these few units, the Siege Companies of the Royal Monmouth and the Royal Anglesey R.E. were coming oversea, and by December, 1914, a

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number of Territorial Fortress Companies had been mobilized and equipped for service. Some had already landed in France.

From these small beginnings, there gradually developed a Corps R.E. organization under the hand of the Chief Engineer, but always in those first two years there was a shortage of R.E. labour. As new Army Corps were formed (the Vth Corps was formed in April, 1915, and the VIth in early June), the Chief Engineer's staff was increased by three field engineers and a second clerk, or draughtsman. One of the field engineers was to act as Staff Officer to the Chief Engineer, but a regular R.E. officer was detailed for this appointment, if possible. The other two field engineers were given some special task, such as the road-repairing work, or the water supply.

The Staff Officer also acted as Stores Officer until resources expanded, and had much the same duties as those of the Adjutant to a divisional C.R.E.

By the spring of 1915 Corps had become more or less permanently fixed in their areas, and engineering problems could be organized and tackled on systematic lines. The areas included large " hinterlands " which gradually filled up with new R.F.C. squadrons, casualty clearing stations, rest camps, etc.

At this period, road work was perhaps the most important of of the C.E.'s duties. The rapid increase of motor transport knocked the bottom out of the French roads, fine as they were to begin with, and, until railway transport was developed, new sidings built, and the labour organizations at the base increased, the efforts of the Corps engineers to save the roads seemed to have but small effect. A few truck-loads of stone arriving in the area daily were swallowed up at once, and 1915 was well advanced before even the first road roller made its appearance on the Poperinghe–Ypres road, which was the main artery of two Army Corps.

In the northern sector of the British Army, companies of Belgian " Travailleurs " were available and were allotted to the two northern Corps. These units were composed of men too old or too infirm for service in the Belgian Field Army, and were administered in groups under their own Commandants. They were the first labour units met with, and as each of the two Corps referred to had from four to five of these companies attached, the resources of the C.E.'s were very much improved.

Usually these companies were employed in the woods and plantations around Proven, cutting pickets and pit-props, making hurdles and fascines, at which work they were admirable. One company, whose O.C. was an engineer by profession, was employed on the defences of the " Kaaie Salient "—the north-west corner of Ypres—working with a section of the 1st Royal Monmouth Siege Company. Another company did very good work around Elverdinghe and Brielen, constructing breastworks. Their brushwood

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revetments were their "forte." Another company was employed in road repairs. The fact that these companies were self-supporting and only came to the C.E. for work, was of great advantage, as the C.E.'s office is not the place for administrative details connected with units' billeting troubles, etc. Our later organization under Labour Commandants proved the value of the separation of these functions.

About June, 1915, the first of the Labour Battalions arrived. These were R.E. units at first, definitely allotted to the Corps. They were composed of elderly men hastily enlisted, and required "sorting," but they showed a remarkable adaptability. Some of them had grievously understated their ages, but this proved their keenness to serve, and every man found his place.

The Labour Battalions were employed on road work, formation of large dumps of engineer stores, concrete dug-outs in the "Corps Line," and hutting.

The defence works of the Corps Line were largely constructed by siege companies of the Special Reserve, with companies of Belgian "Travailleurs" and Labour Battalions; also by working parties furnished by the cavalry divisions. The greater part of the defences of Elverdinghe in 1915 were built by cavalry working parties, under the Chief Engineer of the Corps.

At this time a Corps would have two divisions, both in the line. There were divisions in reserve in certain sectors, but these were preparing for the Loos operations. There was no clear line dividing the areas for which the divisional C.R.E.'s and the Chief Engineer of the Corps were responsible, but roughly the Corps Engineers worked up to the limits of horsed transport by day.

Divisional workshops began to grow, employing refugee labour, and even Field Companies collected old stationary engines from nowhere, and set up little factories, all intent on trying to meet the ever-increasing demand for trench boards, revetting frames, dug-out frames, etc. But over and above these, the Corps started workshops and dumps on a bigger scale. These were usually situated on a normal-gauge railway, but in some cases a special yard had to be constructed, with sidings laid down, and a large area levelled and metalled.

The Corps workshops gradually superseded the divisional shops for the manufacture of standard articles, as divisions changed more frequently, but the latter always had a considerable field for their own exploitation. At first, the Corps Workshops were manned by a handful of sawyers and tradesmen collected from a variety of units, but as Army Troops Companies arrived, one of these units would be told off to run the whole yard. A varied assortment of articles would be manufactured at these dumps:—trench boards, revetting frames, artillery bridges, Bangalore torpedoes, concrete slabs,

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hutting sections, etc. Almost every Corps had its own design for sectional hutting, until the Nissen hut was evolved and superseded all other types of the smaller sizes. The manufacture and painting of notice boards was in itself a very busy side-line, as any square mile of country would testify.

The Corps dump was kept closely under the hands of the Chief Engineer. His Staff Officer kept daily stock lists, and supervised the flow of receipts and issues. Monthly estimates of requirements were sent in to Army Headquarters, and the unnecessary accumulation or cornering of stores was watched by the C.E. As divisions increased in number, so did the Corps dump in size, and in most cases a separate stores officer was introduced into C.E.'s offices.

Corps workshops are an inseparable part of the Corps anatomy and it would seem desirable that they should be allowed for in War Establishments. Like the company cooks, they have got to be there.

With the increasing number of units, R.E. and others, working under the Chief Engineers, it became necessary to relieve the C.E. of the administrative work, and of a portion of the executive work of the units. In the spring of 1917, C.R.E.'s of Corps Troops were appointed, even with an adjutant, one clerk, and one draughtsman. The C.R.E. also had to deal with the demands for engineer services from the large number of units forming Corps Troops. The C.R.E., who was a Lieut.-Colonel, theoretically commanded all the R.E. units attached to the Corps, but in some cases, one or two units were kept directly under the C.E.

The work of the Corps Engineers may be roughly divided into the following classes, in order of priority :—

i. Defence Works.
ii. Roads and Communications, from the points where the Army or Road Directorates' functions cease, to the divisional sphere.
iii. Water Supply.
iv. Camps and other rearward services.

i. Defence Works.

These began with a few isolated works with one or two open machine-gun emplacements apiece, and strongly wired. Considerable attention was paid to getting a good wire obstacle completed, as a definite stage. "Defended localities" were popular in 1915, and several works reached an advanced stage, with good revetments and trench-boarded floors; but the trench boards were usually removed for fuel, and "resident" caretakers became necessary. Defence works deteriorated somewhat rapidly; horses out for grazing were frequently seen damaging parapets, and two-legged trespassers were also to be reckoned with; therefore it is not

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extravagant to spare a few elderly or non-robust men to look after these works and keep them in repair. The amount of work which can be put into the "Corps Line" varies very much. Labour is never forthcoming as plentifully as a C.E. could wish for, but in the case of some of the Corps which occupied their sectors continuously for a year or more, as they did in 1915 and 1916, the lines were in a very advanced state, and were provided with concealed machine-gun emplacements, deep dug-outs and other shelters. Before machine-guns became plentiful, the leading principle was to obtain cover from which rifle-fire could be developed to its maximum; then came an era of carefully sited machine-gun posts in the parapets; later, the machine-gun posts became more cunningly disposed in unlooked-for places, and later still came the principle of siting machine-gun posts and wire entanglements designed to shepherd the enemy towards the machine-guns, leaving the earthworks to be developed as a somewhat secondary stage. Pill-boxes were introduced into defence lines in 1918, and the camouflaging of these became a source of great interest.

In the strenuous days of 1918, when defence lines grew up, one behind another, with astonishing rapidity, the C.R.E.'s chief work was the supervision of the Corps line; large scale plans were made of the works in progress, and were revised every week to show the state of completion. Army Troops Companies were employed on the machine-gun emplacements, screens, look-out posts, revetting, draining, etc., while labour companies furnished the bulk of the working parties. Officers of the Tunnelling Companies, temporarily out of their own job, were lent to supervise sectors of the line.

ii. Roads and Communications.

Until the formation of the Roads Directorate, Chief Engineers were responsible for very large areas, and were dependent on their own resources for labour. Material was distributed by the Army, and was delivered at certain railheads selected for the purpose, and formed into "road dumps." The road work was at all times very heavy, and there were always urgent demands for more and more material. Not infrequently the sites for camps would be selected at considerable distances from any roadway, and after a week or two of occupation, piteous appeals for road-making would come from the occupants who saw themselves getting cut off in a sea of mud. The only remedy for these cases was to give them fascines and a little help, with which their own labour could do something until their plight could be properly attended to.

On the subject of the roads, practically the first lesson learnt, at any rate on the Flanders side, was the necessity of shoring-up the sides before adding fresh metal. Most of the roads consisted of a

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pavé centre with unmetalled strips of varying widths at each side—"trottoirs cyclables" was the local name for them. These sides naturally took a lot of traffic at the outset, motor cars and lorries monopolizing the pavé. The side tracks, of course, soon became quagmires; their outer edges fell away into the ditches, and their inner edges sank and let down the edges of the pavé in its turn. The sides having been shored up, it became possible to fill in the soling, and then the metal.

On communications, the Corps had a variety of work. There was an early demand for trench tramway. One of the divisions in the Ypres sector utilized wooden rails, made in their own and the Corps workshops, until the 60-cm. decauville track became a normal supply. The wooden rails were supposed to deaden the sound of the trolleys, but they were so frequently damaged that they were discarded as soon as they could be replaced. The "points" were armoured with biscuit-tin sheets. Still, there was a great advantage in any sort of tramway which would help to reduce carrying parties, and therefore reduce casualties.

In some sectors, Corps tramways developed extensively, notably in the XVII Corps sector north of Arras. In this part, a 60-cm. decauville system was laid down, with its base close to the main dump, and its railheads in the support line. Trains were made up of two or more bogey trucks and drawn by two mules. The track ran on the open ground. The carrying parties saved thereby meant economy of life and better rest for the tired battalions out of the line. The maintenance of the system was light; traffic went up by night, and the organization was the object of visits from all parts. Curiously enough, in the sector immediately to the south, an entirely different set of conditions was met with. There the town of Arras enabled horsed transport to go up by night to Brigade dumps within 600 or 700 yards of the front line. A tramway was laid in this sector in a specially widened trench, but it was not popular and was little used; a tramway in a trench very quickly gets blocked.

As a rule Corps tramways were limited to supplying the heavy artillery positions. Special tramway companies were formed in 1917, and these worked under Corps tramway officers. By 1918, the tramways were intimately connected with the light railways, which were part of the whole system of Transportation.

In position warfare, tramways have many uses, and although in the forward area their maintenance may require a permanent repair gang, it was often the case that their use over shell-pitted areas of mud saved carrying parties, while during a battle the wounded could be brought back at any rate a few degrees more comfortably than they would be carried by hand over the terrible ground which formed the Ypres Salient in the winter of 1917. Such tramways as these will usually fall within the province of the divisional C.R.E.,

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but the Corps may have the base-end of the system to look after.

On the formation of the Roads Directorate, the responsibilities of Corps Engineers for roads became reduced, and the forward limit up to which the Director of Roads was responsible, or what was called the D.G.T. line, was advanced to within two or three miles of the front line. This left the Corps Engineers with the task of making the planked or corduroy roadways, a form of road surface which had the great advantage that the planks could be taken up and used again as the more permanent road metalling advanced. In the Ypres Salient in 1917 several miles of beech-planked roads were built by Corps Engineers.

Bridges.—During the days of stationary warfare, very little bridging work fell to the Corps Engineers, but in 1917, when the Germans retreated, the demand for bridges became very prominent. Most of the work was deliberate, *e.g.*, replacing the bridge over the railway at Arras station, carried out by an A.T. Company in April and May, 1917. In August, 1917, there were fresh bridges required over the Ypres canal, and at various other places. But it was not until the great days of August, 1918, and onwards that the arrangements for heavy bridging really became put to the test. Then the work of the Corps Engineers became chiefly road-repairing and bridge-building. There were many more bridges than units to build them, and Tunnelling companies were lent to Corps to help in the work. In some Corps, a specially selected A.T. Company was told off as the Corps Bridging unit, but in most cases bridge-building was allotted to whichever R.E. unit was next available. Corps Bridging officers were appointed to look after the issue of available materials, and to advise generally.

iii. Water Supply.

As with the other services, this began in a small way. One of the Field Engineers would be told off to develop the local resources —clearing wells, digging new ones, fixing up pumps—either hand or motor-driven—on the more prolific wells, borrowing labour from Army Troops Companies. Then came a demand for better organized horse-watering places, with long troughs and metalled standings; schemes for providing for the accommodation of the cavalry divisions in view of big operations; and special filling points for water-carts and water-lorries. In the Somme operations, the task of carrying water supplies forward with the advance entailed a vast amount of work which was usually carried out by the Army Troops Companies of the various Corps. Water-columns formed of lorries carrying 300 and 400 gallon tanks and pumps were organized as G.H.Q. units for emergencies, and arrangements for filling these columns were made by the Corps.

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The multiplication of pumping stations—every village would have one, if not more—which had to be manned by sappers, put a strain on the Army Troops Companies, and later on personnel from the Electrical and Mechanical Companies took charge of a large number.

iv. CAMPS AND OTHER REARWARD SERVICES.

Under this heading came many varied calls for engineer work. The erection of huts was largely done by unskilled labour, with sappers distributed as far as they would go. Units were naturally very keen on getting themselves housed, and would apply to C.E.'s for immense quantities of materials. Some units did remarkably good work in erecting their own huts and devising horse-shelters, and recognizing that there were not enough sappers to go round, they set to without delay. Heavy batteries were handicapped in this respect, as their men were continually at work and had few opportunities of tackling such things as horse-shelters. Batteries multiplied so rapidly, and moved about so frequently, that it was really worth while to tell off an R.E. officer to cater for them entirely, both for work at the battery positions and at their wagon lines. In 1917 and 1918 there was more of everything, and it became possible for more or less permanent hutting parties to be told off, and regular hutted camps could be built methodically. But the number of units to be provided for in the Corps area became legion, and demands could not all be met. There was a good deal of waste of material, owing to the quantities demanded being several times more than were necessary.

It was a safe rule to divide all demands of this class by fairly large factors, yet any camp would show reasons why supplies wouldn't meet demands. There is no clear remedy for this state of things: thrift is not a national characteristic, and the average Corps dump looks a perfect gold mine of materials to the unit newly arrived in the area and thinking out its housing schemes.

Something might be done in the way of standardizing such things as small accessories, cook-houses, ablution sheds, etc., etc. Huts, of course, were standardized, but the odds and ends were not, and handy reference lists of materials required for, say, a battery cook-house, would tend to check exorbitant demands. No S.O.R.E., working thirteen or fourteen hours a day, can look closely into all the demands which come in for stores.

"Bunking barns" became a very active item in 1916 and 1917, and when operations on a large scale were imminent, every barn that could stand it was fitted up with two, three, or even four tiers of bunks. These wire-netted tiers were of various types according to the materials available, and large parties were at work on them

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Some healthy rivalry grew up between "resting" Field Companies and A.T. Companies as to the number of bunks completed in a day, and in one Corps area on the Arras sector in the winter of 1916 as many as 1,100 bunks per diem for several days were completed.

Aerodromes, situated some distance in rear of Corps Headquarters, called for a good deal of engineer work, although the squadrons did an immense amount for themselves. Usually, the R.F.C. units asked for a few sappers to be attached to them on loan; but the practice of parcelling out A.T. Companies among various other units, schools, etc., is unsound, and leads to a great reduction in the available engineer personnel at disposal. It also leads to the detachment being used for other purposes than those for which it was detailed; it takes sappers away from their own officers, and leads to waste of time and material. Whatever the job that has to be done, the sappers must work under their own officers.

Casualty clearing stations are on the C.E.'s list. These require many services; good entrances and exits for ambulances; plentiful water supply; clean duckboard paths; good lighting in the operating ward or tent; concrete floors at the cook-houses; destructors; comfortable quarters for the nursing sisters; baths; racking for stores and equipment, etc., etc.; all of which need R.E. assistance.

It was astonishing how readily a C.C.S. unit would achieve things for itself; the personnel always included someone with the necessary skill, but no units were more grateful for any assistance that could be given.

Cinemas must not be omitted. A Corps Cinema was a recognized adjunct to Corps Headquarters. They were usually of modest dimensions, and did not appear on the scene until all divisions had been well supplied.

Prisoner of War compounds were also Corps matters. These grew to be very elaborate, and of necessity had to be self-contained. Similar compounds were required for native labour companies to keep them apart.

Ammunition dumps were built for Corps purposes, usually on a roadside, but several were large affairs requiring metalled roadways and shedding. Light sheds of poles and curved corrugated sheets for the roofing were put up with unskilled labour. A standard pattern was evolved towards the close of the war which was capable of very rapid erection.

Corps Reception Camps were necessary for the reception of drafts and partially-trained reinforcements. Corps Rest Camps, Corps Schools of all kinds, Corps Railheads, Mobile Veterinary Sections, etc., were all items of importance.

Town Majors, too, had calls on the Corps Engineers; houses damaged by shell fire or bombs required pulling down or shoring up; cellars needed stiffening or opening out.

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In 1918, when the great advance began, a new form of engineer work arose; villages which had not been wholly wrecked had a few houses which could be patched up, re-tiled, and made habitable for troops. Tiles were collected from the less promising houses; holes in the walls were patched over with any handy material, and debris cleared out. A company working at this in small groups could in a few days increase the billeting possibilities very considerably.

The catalogue of work which falls, or may fall, to the Engineers of an Army Corps is practically without end. In such a theatre of War as France, the very existence of civilized conditions involved a wide range of additional works, in order to cater for the enormous numbers of troops quartered in the restricted areas. The result was that there was more than ever a need for engineers' work, and every variety of it.

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CAPTAIN LIDDELL HART AND LIEUT.-COLONEL BOND

A Summary and a Judgment.

By COLONEL J. F. C. FULLER, D.S.O.

INTRODUCTORY NOTE.

THE Editor of *The Royal Engineers Journal* has asked me to sum up and attempt to give a decision as to the value of the theories propounded by Captain Liddell Hart and Lieut.-Colonel Bond, in this *Journal* during the last two years.

The articles for my consideration are as follows :—

(i) " A Science of Infantry Tactics." Captain Liddell Hart. Vol. XXXIII. No. 4. April, 1921, and Vol. XXXIII. No. 5. May, 1921.

(ii) " A Study of the New French Infantry Regulations." Captain Liddell Hart. Vol. XXXV. No. 5. May, 1922.

(iii) " The Tactical Theories of Captain Liddell Hart (A Criticism)." Bt. Lieut.-Colonel Bond. Vol. XXXVI. No. 3. September, 1922.

(iv) " Colonel Bond's Criticisms. (A Reply)." Captain Liddell Hart. Vol. XXXVI. No. 5. November, 1922.

(v) " The Tactical Theories of Captain Liddell Hart (continued)." Lieut.-Colonel Bond. (Unpublished).

It is with some diffidence that I have agreed to carry out this task: first, because my time is very limited; second, because during the recent war my work was on the staff; thirdly, because I know Captain Liddell Hart, but have not the pleasure of knowing Colonel Bond; and fourthly, because Colonel Bond's final criticism has not been published. I hope, however, that, if I do an injustice to either side, it will not be considered wilful and that, to defend myself, I shall not be forced to assume the attitude of a contracting funnel.

In order that the reader may logically follow me through this paper, I intend to divide it as follows :—

Part (i) The tactical theories of Captain Liddell Hart.
Part (ii) Certain tactical views of Colonel Bond.
Part (iii) A criticism of the theories of Captain Liddell Hart.
Part (iv) A criticism of the tactical views of Colonel Bond.
Part (v) Judgment.

Such quotations as I may make from Colonel Bond's unpublished paper I will place in square brackets.

PART I.—THE TACTICAL THEORIES OF CAPTAIN LIDDELL HART.

The tactical theories of Captain Liddell Hart, so far as this *Journal* is concerned, are contained in Nos. 4 and 5, of Vol. XXXIII, and they

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are elaborated from two analogies—two men fighting in the dark, and an expanding torrent of water.

(i) *The Man Fighting in the Dark.*—In order to establish a science of infantry tactics, Captain Liddell Hart postulates as the simplest and most realistic form of war two men fighting in the dark. From this postulate he elaborates five battle principles:—

(*a*) The principle of protective formation.—Each man extends one arm in front of him.

(*b*) The principle of reconnaissance.—Each man attempts to grip his opponent's throat.

(*c*) The principle of fixing.—Once the throat is gripped it is held firm.

(*d*) The principle of decisive manœuvre.—Whilst the "fixed" man is trying to free himself, his adversary knocks him out.

(*e*) The principle of exploitation.—Before the knocked-out man can recover his opponent renders him powerless.

Captain Liddell Hart next attempts to simplify the whole process by dividing the above actions into two categories—guarding and hitting, to which he attributes two governing principles, those of Security and Economy of Force.

So far his premises; all that now remains to be done is to apply them.

Security.—Security is of two kinds—material and tactical. The first is security against physical loss and the second against the loss of tactical energy. Security is gained by an application of the first three battle principles.

Economy of Force.—Economy depends on expending only the very necessary force on the application of the first three battle principles and the bulk of it on the remaining two.

From these considerations it follows that every front line unit in battle must be divided into two parts—a forward unit to reconnoitre and fix, and a manœuvre unit to punch and pursue, the strength of the punch depending on the perfection of the fixing.

Having settled on his protective formation, the commander must attempt to accentuate his strength by surprising his enemy, by speed of movement, by momentum, by searching for a "soft spot" to hit at, by husbanding his men and by arranging for mutual support and for exploitation.

As Captain Liddell Hart finds that the pre-war system of infantry attack not only does not maintain these principles, but violates them, in place of a battle line reinforced at those places where the greatest losses are experienced, he suggests a battle front of infantry groups, based on the platoon, which, on account of the extensions between them, will be in a position to manœuvre and discover the lines of least resistance to their advance. These groups he calls human tanks, because they possess power of movement, offensive

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power and their formation protects them like armour. He then lays down a series of maxims for the platoon in the attack which, in the main, are based on searching for a "soft spot," and when it is discovered, of pushing ahead irrespective of most other circumstances.

(ii) *The Expanding Torrent System of Attack.*—The "soft spot" must be found, consequently, "we must feel and test the position everywhere, and endeavour to push in the weight of our reserves where a weak spot is found or made. . . . Hence we must create a scientific system of attack which will reconcile and combine *speed with security.* The breach must be widened in proportion as the penetration is deepened by automatically progressive steps, beginning with the platoon and working up to the brigade." The writer then deduces from the analogy of a torrent breaking against a dam four principles of attack :—

(*a*) The forward sub-unit makes or finds a breach and, followed by the manœuvre body, pushes straight ahead.
(*b*) The forward units on its flanks, if held up, send their manœuvre bodies through the breach and widen the gap.
(*c*) The rear units press through the gap and deploy—expand.
(*d*) The held-up units, directly resistance is broken, follow through the gap as manœuvre units.

By means of these principles the whole process of attack becomes automatic, once the soft spot is found, and confusion is reduced to a minimum.

"The defence is simply the attack halted," consequently protection against the expanding torrent is to enclose it in a "contracting funnel" of fire.

Part II.—Certain Tactical Views of Colonel Bond.

The line to be adopted in searching for a solution to future tactics is laid down as follows, by Colonel Bond :—

["A certain experience since the war of the training of troops, of being instructed and of instructing, has led me to think that the watchword of our training for war ought to be 'reality,' that the test of everything which we teach and practise must be : Can the troops really do this? with the weapons and munitions, etc., with which mobilization will actually provide us, with the men we have, against the actual enemy we are training to fight, in view of the methods and weapons which he may be expected to use, is it probable that this method will succeed? . . . If this is true, then the great enemy to our training will be found in 'formalism.'"]

Here I think is presented to us the key to the secrets of Colonel Bond's tactical theories of war, which apparently are based on the lessons of the recent war, for he writes :—

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" What, then, are the true tactical lessons of the Great War? I say, unhesitatingly, that they are the same as for every war in which we have been engaged. We should have learnt three things: The psychology of our soldiers, the material and moral effect of existing weapons in various circumstances, the necessity at all times of thinking objectively, that is to say, of basing action not on theories—on what we should *like* to do—but on the hard facts of the particular case—on what we *can* do . . . Armed with this knowledge, with this habit of thought, with the true spirit of the basic principles of war, and with the will to win, our leaders ought to be certain of victory, wherever their duty calls them."

We must, therefore, cultivate an " objective outlook " and think the thoughts of the front line soldier before we can theorize. The reason why we do not do so is that " The true lessons are avoided because they are of their nature spiritual, difficult to express, difficult to teach, impossible to draw." Formalism can only lead to mental inertia, [" to the retention of obsolete methods beyond their time, to our entering in a new war with the methods of the old, to preparation for the wars of the past rather than for the wars of the future."]

What is required in the place of formalism, which aims at establishing a method, is tactical judgment, [" because in war there is none but the particular case "]. In the past judgment has on the whole been disappointing. [" How to combat this tendency, how to create this judgment: that is the problem."]

From the above condensed ideas on tactics and training I will next turn to Colonel Bond's criticism of Captain Liddell Hart's methods.

Briefly, the charges he brings against this writer are :—

[(i) " That, at the close of a great war, he " has " chosen to base his doctrines not on the experiences of that war, but on unsound arguments drawn from analogies."

(ii) " That he " has " ignored the human factor."

(iii) " That he " has " proposed a tactical system, to be imposed on all commanders up to Brigadiers, involving the use of set and invariable forms.

(iv) " That he " has " intended that system to be universal, regardless of very varying conditions of the Empire."]

The Expanding Torrent system is cast aside: " can there be anything more unlike than inanimate water bursting through a passively resisting dam, and a trickle of tired men, torn and bewildered by the psychological impact of battle, passing through a gap in an actively resisting hostile front to meet fresh, unknown and unlocated dangers ahead? The two things are totally dissimilar."

With the drying up of the expanding torrent we are left with no solution to the infantry attack against a highly-trained and well-

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equipped antagonist save that of [" tanks or the support of very strong artillery."]

To accentuate these views Colonel Bond quotes the opinion of an infantry officer of much experience. This officer says :—[" Not only were great depth and the dispersion of defensive posts forced on us by the great power of the artillery and mortars of the attack, but the possibility of penetrating such a system is absolutely dependent on the possession of tanks or of very powerful artillery support. People seem to forget our experiences in the early days of the war. To attack a regular enemy without using tanks or without the support of plenty of artillery would be to repeat our experiences of 1914–15 with the chances five times as heavily against us. Penetration such as Liddell Hart appears to consider normally possible is, I consider, only feasible under two conditions, *i.e.*, either the posts must be very badly sited or they must be prevented from functioning by very heavy artillery covering fire."]

Part III.—A Criticism of the Theories of Captain Liddell Hart.

The main premises of my criticism on the above two parts of this paper will be the problem Captain Liddell Hart set out to solve, namely, can a science of infantry tactics be established? It may be possible to establish such a science, personally I do not consider it feasible, for though I believe in a science of war, I consider that tactics are the application of this science to the ever-changing conditions of active operations. As Captain Liddell Hart will probably disagree with me, I will first of all examine his scientific method as outlined in " The Man Fighting in the Dark."

He starts by assuming that the fundamental principles of war may be deduced from a fight between two men. With this I agree. Then he adds, " under similar conditions, such as in the dark," and so spoils his premises by selecting a special case. From these spoilt premises he declares his five battle principles.

I will take two cases of two men in the dark which I believe will show that his conditions are special and not general.

(i) It is dark and two men are placed on Hampstead Heath, one at the eastern extremity and one at the western ; they are told to find each other and fight Does warfare resemble such an operation? No, because, not being cats, they might wander about for months and never be near each other. Arm these men with knives, would they seize each other by the throat and then deliver the decisive blow? No, they would immediately deliver a blow, decisive or otherwise, on contact.

(ii) Two men are placed in a room and the lights are turned out It is dark and I am one of the men, what

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would I do? I would take my shoes off and feel my way to a corner, so that I may gain flank protection. I would place one shoe two yards to my right and the other two yards to my left, and my coat I would take off and place two yards in front of me. Then I would crouch low in my corner and listen. Sooner or later my adversary, following Captain Liddell Hart's method, with left hand outstretched will approach me, strike against my entanglement and in an instant I would launch my attack, aiming a blow at where I calculated his solar plexus was. What have I done? My object is to knock him out; first, I secure myself by selecting a corner and by covering my flanks and front by means of my shoes and coat; secondly, I economize my strength and opportunity by not wandering about in the dark; thirdly, I concentrate my strength by crouching low, and fourthly, when he is near me, I move with lightning speed, surprise him and deliver my offensive. All the means at my disposal I have used—walls, clothing, ears and muscles, and I beat him by better co-operation. I have, in fact, carried out the principles of war, all of them, as laid down in the Field Service Regulations, but I have not reconnoitred, I have not fixed and I have not exploited. I have assumed a "protective formation," and have carried out a "decisive manœuvre"—I have guarded myself and I have knocked out my adversary.

From guarding Captain Liddell Hart deduces the principle of security, with this I agree; and from hitting he deduces the principle of economy of force, with this I disagree; for from hitting I deduce the principle of the offensive.

Now as to his battle principles. The first two—protective formation and reconnaissance, in my opinion, fall under Security, and the last three—fixing, decisive manœuvre and exploitation are special applications of the Offensive. Then, as to the attack principles. Surprise comes under Surprise; speed and momentum under Movement; the soft spot under the Objective; husbanding under Economy of Force; mutual support under Co-operation and exploitation under the Offensive.

All the F.S.R. principles of war are, therefore, included, not as general truths, but (and certainly in several instances) as special cases. Here, in my opinion, is Captain Liddell Hart's initial mistake, and to me it appears to confuse the whole issue of his argument, for several of his principles are not principles, that is general truths, but rules which admit of exceptions. On these faulty premises he bases the theory of his infantry tactics. These tactics I will now examine.

Very rightly, in my opinion, Captain Liddell Hart criticizes adversely our pre-war infantry tactics, which were based on the idea

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of maintaining a continuous firing line which though it started weak ended strong, so that fire supremacy might be obtained. These tactics were, in fact, but those of an advancing line of pikemen, they were antiquated and the war proved them most costly and totally unsuited to modern weapons. Nothing daunted, Captain Liddell Hart sets out to solve the difficulty, and he finds his answer in reducing the size of the human target by endowing the unit with power of manœuvre—power to make use of ground for cover (guarding) and for fire (hitting) and the result of combining these two is protected mobility.

So far I consider his ideas excellent, but now he jumps the rails of reason. So carried away is he by his discovery that movement, weapons and protection are the elements of war, that he not only calls his attacking infantry groups human tanks, but treats them as if they actually were tanks. Bullets and the fear of bullets are now lost sight of and his groups manœuvre and search for the "soft spot" as if they were encased in half-inch armour plate. The "soft spot" found, and it may only be a few hundred yards wide (and be it well remembered that a machine gun can bring effective fire to bear at a range of 2,000 yards) the human spate advances, it expands outwards, widening the breach, and reinforcements flow through the gap. What do we see here, not the outline of an infantry attack, but that of a tank attack, for one of the commonest uses of tanks, once they have penetrated an enemy's front, is to move them outwards, in order to widen the breach in the enemy's line. The tank can do this, because it is impervious to bullets; the infantry soldier cannot, because every bullet which goes home puts a man out of action. The man in the tank does not care a damn for bullets, the man outside this machine does not care a damn for anything except bullets. I am here taking the simplest case, but even if we add artillery fire, though the movements of tanks become more difficult, so also do those of the attacking infantry.

Setting out to bless the infantry, I cannot help feeling that Captain Liddell Hart has ended by cursing them, and by cursing them he has revealed to us all a system of tactics admirably suited for bullet-proof men and only such as these can rightly be called human tanks. He is, in fact, if not in word, a tank enthusiast.

Part IV.—A Criticism of the Tactical Views of Colonel Bond.

I will now turn to Colonel Bond. In attempting to criticize his views I am at once faced by a real difficulty, namely, a total lack of tangible pegs whereon to hang my criticism. Captain Liddell Hart offered me many "soft spots," Colonel Bond offers me none, for I am unable to differentiate between what is hard and what is soft in his argument. I am enveloped in a thin mist of platitudes

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and when I snatch a handful of it and open my hand there is nothing there.

It is no good telling me, or any soldier possessing a normal intelligence, that the true tactical lessons of the Great War are the same as for every war in which we have been engaged. This is really too easy, and though philosophically it may be true, to the working soldier it is utterly false. It is no good saying to a watchmaker's apprentice that the art of watch-making consists in constructing a machine which records time, for what he wants to know is *how* to construct a watch. On the shelf behind me, as I write, stands a tall foolscap volume of notes on tanks. In it are recorded over one thousand lessons as regards the use of tanks. I agree that all these lessons could be boiled down into one lesson—the conservation of tank energy in war. Suppose, I tore out the present pages of this book and substituted one page with the above seven words in it, what use would the book be? To myself, who possess some knowledge of tanks, I can frankly say it would be absolutely useless, how much more so to a tank section commander struggling to learn his trade.

I know perfectly well that *a* lesson of every war is the understanding of military psychology and I know also that Shakespeare is a noted poet. Further I know that it is perfectly useless to give Shakespeare to a child who cannot spell out the alphabet, and how many soldiers can spell out the alphabet of military psychology or even can define the words?

But enough, for having now belaboured the philosophic formalism of Colonel Bond, I can turn and shake him by the hand when he says that, if we are armed with "the true basic principles of war," and the will to win, we need never dread defeat.

"We must, therefore, cultivate an objective outlook," and I cannot understand why Colonel Bond has not done so. The object aimed at by Captain Liddell Hart is the establishment of a science of infantry tactics. Colonel Bond tears this science into waste paper, but replaces it by nothing tangible. Had I been Colonel Bond and believing as he does in the basic principles of war, I should have tackled Captain Liddell Hart's argument somewhat as follows:

The object is to defeat the enemy and the means are infantry. What must the infantry do? They must be able to move (principle of movement), hit (principle of the offensive) and guard themselves (principle of security). Then I would in detail examine Captain Liddell Hart's tactics and would discover that the "soft spot" in it was guarding, and that, on account of the extreme difficulty of moving men forward in face of determined machine gunners, movement would cease and, with the cessation of movement, the remaining four principles of war—surprise, concentration, economy of force and co-operation—would be rendered inoperative.

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I would then tackle the "soft spot." How can I make this spot a hard spot. Smoke clouds—no, these won't stop bullets and will adversely affect movement; scattered formations—no, these won't stop bullets and will detrimentally affect leadership and consequently the gaining of the objective; artillery covering fire—yes, but this may violate the principle of surprise; armour—yes, but won't this reduce movement?—By Jove! I've got it—the tank. One moment . . . a man in a tank is very much a man in the dark . . . and the expanding torrent . . . of course, of course . . . why it is as clear as a pike-staff. I would now step forward and shake Captain Liddell Hart by the hand.

And this, I am glad to say, is exactly what Colonel Bond does, for after waltzing round his opponent through many pages in which he sticks pins into the "soft spots" of Liddell Hart's tactics, he also, in the words of a friend, proclaims himself a tank enthusiast.

JUDGMENT.

Having now said so many unkind things about both writers, and still fearful of the "contracting funnel," which I feel will soon close on me like the iron maiden of Nuremberg, I wish to make amends and to vanish like a man in the dark, but without having my throat pinched.

I admire Captain Liddell Hart's pluck. He has set out to champion the P.B.I.; he has liberally sweated blood to do them a good turn, and in doing so he has shown a fine spirit. We still have infantry, and the bulk of our army is infantry, and we have very few tanks. It follows, therefore, that, if we go to war in the near future, we shall have to employ infantry; the question consequently to be answered is how are we going to employ them? In my own opinion there can be little doubt that Captain Liddell Hart's method of tactics is a great advance on the method of 1914, for, even if it fail, it will not fail at so great a cost. A method it is, and a method we must have, for it is method which cements a mob into an army.

I admire Colonel Bond's offensive spirit, I am one with him as regards the danger of slavishly following rules and formalities and I shake him by the hand every time he reminds us that when we set out to think of war we must begin by thinking in terms of men. The value of judgment he accentuates and there can be no doubt as regards its value. By judgment we discover truth and then when we have discovered it we inculcate it by method.

Here ends my criticism and my applause. It has been an interesting study, this struggle of two men in the dark. Round the room they creep with their left arms thrust forward . . . there is a throttling grip on each other's throat . . . I can stand the strain no longer . . . I turn up the lights . . . and what do I see? Two men wringing each other's coat tails (loud laughter). Case dismissed!

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NOTES ON INSTRUMENT TRANSFORMERS.

By LIEUT. E. A. BARCLAY-SMITH, R.E., B.A. *Cantab.*

ALTHOUGH they play an important rôle on every alternating current switchboard, instrument transformers receive but scant attention in most text-books.

The following notes may prove of some service for a fuller comprehension of the subject.

In addition to their recognized function of transforming high voltages and large currents into smaller and more easily measurable values, instrument transformers play another important part in high-tension transmission, namely, that of insulating the instruments from the high-tension circuit.

Current transformers may have to " take " large currents without much drop in potential. On the other hand, potential or voltage transformers may have to " take " high voltages, but at the same time pass little current.

A bar of conducting metal will " take " a large current with very little voltage drop, but in order that a piece of apparatus may " take " a high voltage and yet pass little current, a large number of alternating flux turns must in some way or another be built up to oppose the high voltage, otherwise it will be necessary to use a large number of resistance coils.

Hence a potential transformer designed to contend with high voltages is of necessity a larger, heavier and more costly piece of apparatus than a current transformer designed to accommodate large currents, provided the output required is small, such, for instance, as would be necessary to work a voltmeter or an ammeter.

It is, therefore, a distinct advantage that under most circumstances more of the latter than of the former are required.

For example, in the case of a three-phase system sub-station where a number of feeders are taken off the mains, three potential transformers only will be required to give the voltages between lines, since these are identical for each feeder. On the other hand, three current transformers would be needed for each feeder in order to ascertain the load taken by each feeder and, more important still, to discover if any feeder is taking an unbalanced load.

In discussing instrument transformers it is necessary, in the first place, briefly to set out the ordinary characteristics of a transformer.

If to the primary terminals of any transformer an alternating

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P.D. of value V_1 is applied there is induced a back E.M.F. E_1 in the primary windings, an E.M.F. E_2 in the secondary windings, and a P.D. value V_2 at the secondary terminals. Furthermore, if the secondary circuit is such as to permit a current I_2 to flow in it there will be induced a balancing current I_b in the primary in addition to the magnetizing current I_o which is independent of secondary conditions.

The relations between the foregoing quantities (all R.M.S. values) are as follows* :—

$$\bar{E}_2=\bar{V}_2+\bar{I}_2\bar{Z}_2 \qquad \bar{V}_1=\bar{E}_1+(\bar{I}_b+\bar{I}_o)\bar{Z}_1$$

$$\frac{E_1}{E_2}=k=\frac{I_2}{I_b}$$

where k is the ratio of the primary to the secondary turns, and Z_1, Z_2 are the internal impedances of the primary and secondary windings. The internal impedance of a winding is considered to be the resultant of the resistance of the coils and the reactance due to leakage flux.

For primary pressures over 4000 volts, potential transformers having, of necessity, a large core and many turns in the primary winding with some of them at a high potential difference, are usually of the core type and oil insulated and cooled. For three-phase work three-phase potential transformers are made with star-star windings, the neutral point on the secondary side being brought out to a terminal. (*Vide Plate* I.)

For pressures below 4000 volts they may be of the shell type and air cooled. (*Vide Plate* II.)

Potential transformers generally transform down to a maximum pressure of about 100 volts. For primary potential differences of over 4000 volts the secondary turns usually number about 70, but for lower primary pressures may be as many as 120. The number of primary turns is, in each case, as many as will give the correct pressure ratio.

Current transformers for values of k below 1/40 are frequently found to consist of a magnetic circuit surrounding a single primary conductor; the secondary turns, of course, being wound round the limbs of the magnetic circuit. Examples of this type can often be seen on the bars at the back of a switchboard, the bar itself being the primary turn encircled by the magnetic circuit.

In high-tension systems the primary turn sometimes consists of a rod cemented inside a porcelain sleeve which, in addition to supporting the rod, is surrounded by a ring of iron about which the secondary is wound.

* In this and subsequent discussions the effect of harmonics other than the fundamental are neglected; with the flux wave sinoidal the magnetizing current wave is taken to be the "equivalent sine" wave.

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The secondary is well insulated from the primary by such an arrangement.

For values of k of 1/40 (*e.g.* 200/5 amps) and above, the primary may consist of two or three turns wound on a hollow cylinder of insulating material inside which are the secondary windings wound round a limb of the magnetic circuit. In similar transformers made for ratios down to 20/5 amps, the primary consists of a much larger number of turns wound on the hollow cylinder. (*Vide Plate* III.)

A current transformer with two or more primary turns used on an H.T. system of over 6,600 volts is generally immersed in a small oil tank to prevent the primary winding breaking down to earth. The two primary terminals are brought out of the tank through the same porcelain. (*Vide Plate* IV.)

The main purpose of an instrument transformer is to produce a secondary pressure or current having a definite ratio to the primary pressure or current.

When the primary of a current transformer is carrying the line current of a power system, the secondary may be open or short circuited, but the drop in the primary or power circuit caused by the transformer will in neither case affect the main primary current to any appreciable extent. Hence there will be a constant primary current and the primary drop will adjust itself to secondary loading conditions. Thus the amount of primary drop is unimportant and no attention need be paid to primary leakage flux.

The primary current has two functions :—

(1) To provide ampere-turns to balance the secondary ampere-turns.

(2) To provide magnetizing current I_0.

Hence, if the current ratio is to be inversely as the turns, the magnetizing current should be as small as possible.

The magnetizing current depends on the flux which, in its turn, depends on the secondary P.D. Thus, for accuracy, the P.D. required to force the desired current through the secondary circuit should be as small as possible, and for ordinary working conditions the saturation of the iron should be well below the "knee" on the B–H curve.

If an ammeter be placed across the secondary terminals the secondary P.D. will be small and the currents, to all intents and purposes, inversely as the turns. Frequently a few turns of the secondary winding are omitted, thereby compensating for the magnetizing current effect under ordinary working conditions.

When the primary winding of a potential transformer is connected across the lines of a power system, the current in the primary will not affect the main pressure between lines as long as the secondary is not short circuited (in which case the coils would be rapidly

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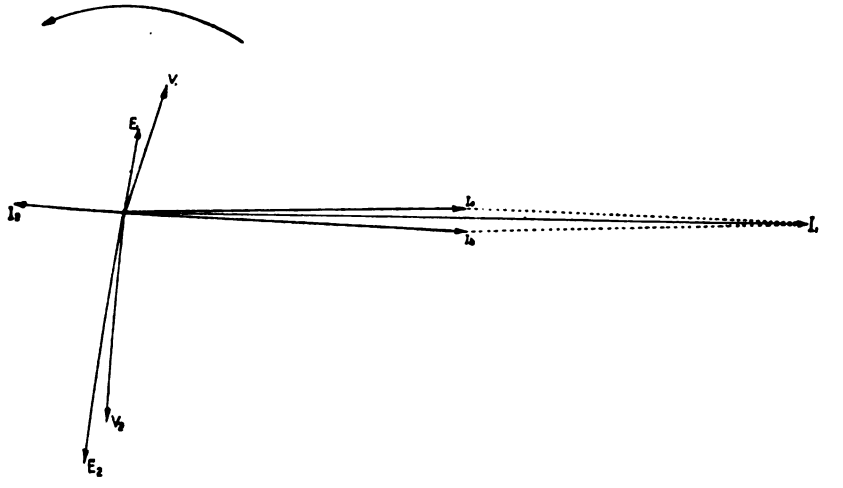
burnt out). Hence there will be a constant primary pressure and the primary current will adjust itself to secondary loading conditions.

From the ordinary transformer equations it is obvious that, if the pressure ratio is to be proportional to the turns, the internal drops in the two windings must be as small as possible. Hence the secondary current should be minimal and the leakage flux very small in proportion to the core flux. To attain these conditions, the core should be saturated at working pressures, and there should be little leakage space between the two windings; at the same time the secondary windings must be well insulated from the primary.

A few turns of the primary winding are often omitted in order that under ordinary conditions the effect of the two drops may be neutralized.

As the name implies, instrument transformers are not intended to transmit much power. Potential transformers, however, as has been previously pointed out, are of necessity fairly large pieces of apparatus, and as their windings must have a certain cross-section for mechanical reasons they can carry an appreciable secondary current, the sole result being that the pressure ratio is altered to some extent.

Sometimes the arrangement is such that the current from the secondary of a current transformer shall work a tripping device in addition to passing through an ammeter. In this case the tripping coils offer a fairly large reactance, and in order that the secondary current may pass, a secondary P.D. leading the current by nearly 90° will be required to overcome this reactance.



Vector diagram for a current transformer, the secondary current of which passes through the coils of a tripping device.

V_1 = Primary P.D. E_1 = Primary E.M.F. I_1 = Primary current.
V_2 = Secondary P.D. E_2 = Secondary E.M.F. I_2 = Secondary current.
I_b = Balancing current. I_0 = Magnetizing current.

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Hence there will have to be a proportional drop in the primary circuit leading the balancing current by nearly 90°. To obtain this drop, a magnetizing current lagging behind the drop by nearly 90° will be required. The balancing current and the magnetizing current will thus be nearly in phase. As the constant primary current is equal to the vectorial sum of the balancing and the magnetizing currents, the secondary current will be very nearly minimal for that particular value of the magnetizing current concerned, and the transformer will be in a condition of minimal advantage.

A case has been known where a current transformer intended to work an ammeter and to trip a switch at full load current was found to produce, on full load, a secondary current of only half the value it would have been had the turn ratio been maintained, and it could not be made to trip the switch by any increase in the primary current, however large.

When a current transformer is to be used for working tripping gear, it should contain several primary turns and be capable of giving a much greater K.V.A. output than the current transformers previously described; as a consequence a larger and heavier piece of apparatus is necessary.

It has been stated that removing an ammeter from the secondary circuit of a current transformer without first shunting the ammeter is a highly dangerous proceeding, since, the secondary being on open circuit, the transformer will form a choking coil in the primary circuit. This, it is considered, would cause a considerable reactance drop across the primary terminals and a correspondingly increased pressure difference across the secondary terminals, with the result that, as soon as the secondary circuit is broken by the removal of one of the leads from the ammeter, a dangerous difference of potential will arise between the lead removed and the ammeter terminal.

This is true in the case of a current transformer capable of a certain K.V.A. output, but the following typical example will show that it is untrue for a current transformer designed for the purpose of working an ammeter only.

In the case of a 2000/5 amp. bus-bar type current transformer carrying full load current at a frequency of 50 cycles, the secondary potential difference when the secondary circuit is broken can be calculated as follows:—

On the primary side there are 2000 amperes and 1 turn.

$$\text{Max. M.M.F.} = 0{\cdot}4 \times \pi \times 2000 \times \sqrt{2} = 3550.$$

Length of magnetic path of flux = 24 in.

$$\text{Max. Magnetic Force} = \frac{3550}{24 \times 2{\cdot}54} = 58{\cdot}3 \text{ gausses.}$$

For Transformer steel B(max.) would equal about 16500 lines per square centimetre.

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Note that the core is saturated.

Cross-section of magnetic path $=0\cdot9$ sq. in.

ϕ = Flux (max.) $=16500\times0\cdot9\times(2\cdot54)^2=95800$ lines.

Effectual secondary E.M.F. $=4\times f\times\phi\times n\times F\times10^{-8}$ volts.

where f = form factor of E.M.F. curve, F = frequency, n = number of secondary turns.

In this case $E=4\times f\times95800\times400\times50\times10^{-8}$ volts, and, the wave being assumed sinoidal, E = 84 volts.

The result cannot be considered a very dangerous voltage.

If the primary current were 100 per cent. overload the secondary potential difference would be less than 100 volts, owing to the saturation of the core.

In the case of a 200/5 amp. current transformer with 5 primary turns, the secondary potential difference on open circuit would be less than 84 volts.

Under many circumstances the secondary circuit of a current transformer is always closed through an ammeter. As the secondary E.M.F. is required to force the secondary current through the secondary winding and the ammeter only, it is never large. As a result, the flux flowing round the magnetic circuit is always small, and in certain designs the necessity for lamination of the core would disappear, since with very low flux densities eddy currents need not be considered.

If the current transformers previously described were made with solid cores, there would be a saving in the cost of manufacture of 25 per cent. However, there is always a danger that some part of the secondary circuit may be broken or by accident be left disconnected. Should such occur to a transformer with a solid core, the latter would speedily heat up and burn the insulation on the coils.

Summary.

1. When the output required is small, potential transformers are more bulky, heavier, and more costly than current transformers.
2. Under ordinary circumstances current transformers are required in larger numbers than potential transformers.
3. Two types of potential transformers are:—
   (*a*) The core type, oil cooled and insulated, used for pressures over 4000 volts.
   (*b*) The shell type, air cooled, used for pressures below 4000 volts.
4. Current transformers have one primary turn for large ratios and several primary turns for small ratios.
5. The magnetizing current should be minimal in a current

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transformer, while the internal drops should be as small as possible in a potential transformer.

6. Low-power current transformers should not be used for working tripping-gear.
7. The statement that it is dangerous to break the secondary circuit of a current transformer is untrue in the case of a transformer designed for the purpose of working an ammeter only.
8. If the secondary circuit is kept closed through an ammeter, it is unnecessary in certain cases for the core of a current transformer to be laminated.

I have to express my grateful thanks to Messrs. Johnson and Phillips for the loan of photographs of transformers which they manufacture, and to Professor E. Wilson of King's College for most useful criticism. There are certain statements in this paper with which Professor Wilson will not agree and for which he cannot be held responsible.

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NOTES ON INSTRUMENT TRANSFORMERS.

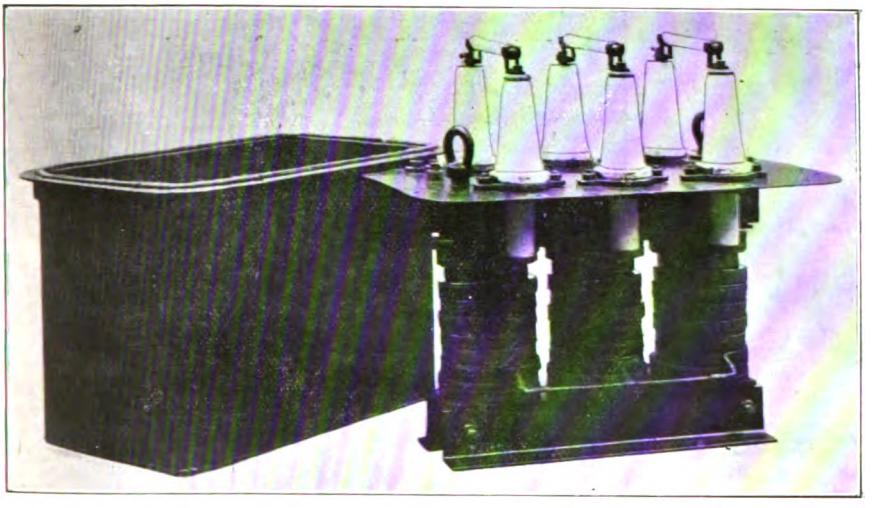

Plate 1.—A 6,600/110 volt, 50 cycle oil cooled and insulated, three-phase potential transformer, with fuses mounted in position, removed from its oil-containing tank shown on left.

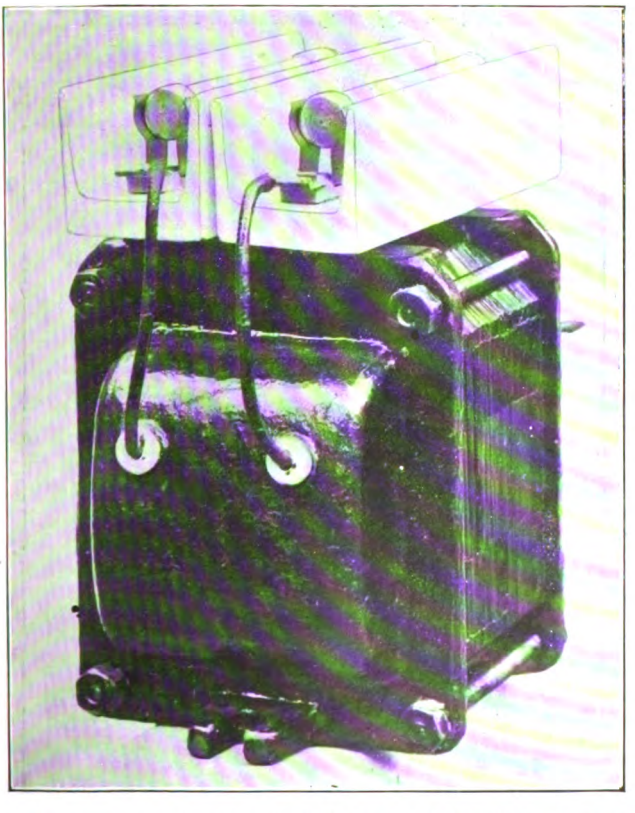

Plate 2.—A 3,300/110 volt, 50 cycle shell type potential transformer, with fuses mounted in position.

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PLATE 3.—A 25/5 ampere current transformer.

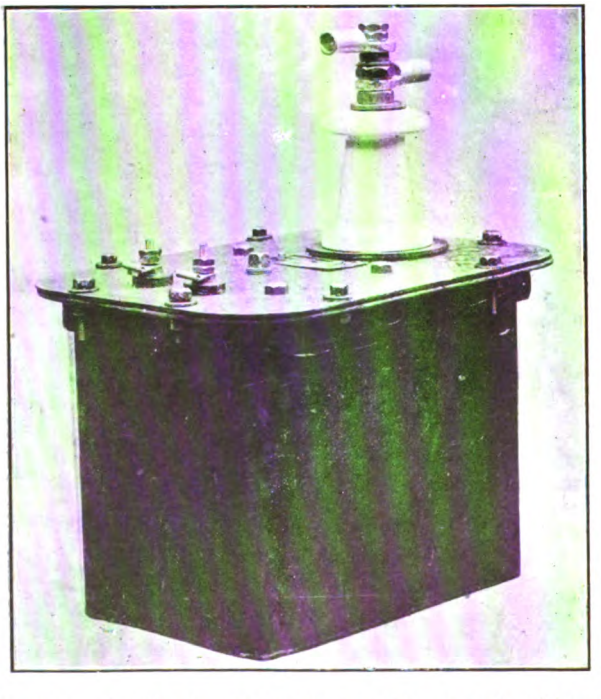

PLATE 4.—A 40/5 ampere current transformer enclosed in an oil tank for use on high-tension circuits.

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THE WAY OF AN EAGLE.

By LIEUT.-COLONEL D. F. M. HOYSTED, D.S.O., R.E.

To anyone who had served in the front line during the last war, it would be a commonplace to say that " it takes a ton of lead to wound a man." And I suppose the average is well maintained in sea fighting, though the unit of success in destruction there is the ship and not the man.

Shooting by Field Artillery at single men was very rarely indulged in, owing to the infinitesimal chances of success and the certain waste of ammunition. I was sniped by a German field-gun at about 3,500 yards while reconnoitring, and it was not till the third round that I was even sure of the nature of the target. What chances of success would an optimistic Gunner maintain for a direct hit from a field-gun on a single man advancing diagonally across his field of fire at 5000?

And the target would only be moving at the rate of from four to six miles an hour, according to his state of mind. Consider a target for a similar gun, but moving thirty times as fast, though five times as large. The chances of a direct hit have decreased six-fold.

These objects are moving in two dimensions, but air fighting has added another, and Gunners who are keen on their art must thank the gods that human beings know so little about a fourth. With an aeroplane moving in three dimensions at anything up to a couple of hundred miles an hour, or from fifty to a hundred yards a second, the barometer of hope in the mind of the most sanguine Gunner must be at something like " forty below." To add to the difficulty of the problem, the target can suddenly arrive by day or night; in fact, the terrors of darkness are greater for the attacked than for the attacker. The chances are, that in the next great war the first notification will not be the cartel of defiance or ultimatum, but a sudden bombing raid of gigantic proportions which will continue throughout the hours of darkness till either the attackers have been scared away or the nerve centres of the country attacked have been so paralysed that the initiative rests with the attackers. Such a raid, if carefully prepared and executed, would be a knockout blow for any but the stoutest heart.

It was with a mind perplexed by this riddle that I attended a

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Senior Officers' Course at the Anti-Aircraft School at Perham Down.

After a fortnight's most interesting instruction, but one slender thread of hope remained in my mind for the defenders during a night raid. It consists of the fact that it has so far been found impossible to eliminate the sound of the hum of the propeller and the roar of the exhaust. Means will, no doubt, be found in the future by science to deaden the latter, but every revolving blade has an inherent vibration which it is impossible to quench, and on this propeller note hangs the whole of our salvation at present.

In daylight fighting the target is certainly visible and can be followed, provided that there is no convenient cloud or mist behind which it can dive for safety. The ultimate range of the 3-in., 30-cwt. A.A. gun and fuze is 21,000 ft.; the gun cannot fire very effectively at a greater angle of elevation than 75° and authorities prefer it at less than 70°. So that the total period during which the gun might be able to bring effective fire on the passing target is limited to a couple of minutes while advancing and another couple of minutes while retiring; this was referred to by "Experto Crede" in the May 1922 number of the R.E. Journal. And, conversely, it would seem that the best chance of safety for the aeroplane passing within easy range of a single gun is to steer a course directly overhead, so that for 30 degrees it is within the safety zone, where it cannot be effectively fired at. If the weather is fine enough the spotters can pick up the target while still be yond range, and there will be time for the heightfinders and deflection predictors to give valuable information to the gun, but otherwise the want of time must preclude the efficient use of the numerous instruments of precision which are necessary to measure movement in three dimensions at such a speed.

The problem for the Gunner is to predict the future position, in space, of the target at the instant when the shell which he has previously sped upon its way to the rendezvous will have arrived at that identical spot and burst. If visibility is good and there is time enough, all the necessary readings can be obtained in a fraction of a minute and applied to both gun and shell; the different manipulations are made as automatic as possible by means of the most ingenious mechanical and electrical devices.

The chances of success, then, depend upon the high degree of training, firstly, of the gun commander and instrument numbers in estimating height and deflections, and secondly, of the gun crew in the rapidity and accuracy with which they can carry out their orders.

By night the problem would seem to be made impossible were it not for the slender thread previously referred to. Sound waves are independent of light or darkness, rain or fine. But without some very sensitive detectors, a searchlight beam could only be thrown

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upon the place where the operator thought he heard the noise. Sound waves move at approximately 1,100 ft. per second, so that, if the enemy is flying at 11,000 ft., and a speed of 150 miles an hour, he has moved approximately 750 yards, or nearly half a mile, from the spot at which were originated the sound waves heard at the gun or searchlight. Each searchlight is supplied with a sound locator, with which a well-trained crew can pick up the target wonderfully quickly on a clear night, and once picked up, three converging searchlights can hold it while within their range and pass it on to the next three in the cordon. And it must be remembered that the aeroplane requires a fairly clear night to bring its mission of destruction to a successful issue.

If our scientific investigations proceed as successfully as heretofore, there does not seem to be any reason why warning of a hostile air raid should not be recorded while the raider is still some fifty miles, or a quarter of an hour's flight, from our coasts. In addition, every class of aeroplane engine makes a different note in vibration. Some are quite easily distinguished by the unassisted human ear, so that there should be no inherent difficulty in recording, on suitable instruments, the difference between all classes of machines.

One night, like Pharaoh, I dreamed a dream; but in my dream the lean years had been followed by the fat years, and there was plenty in the Treasury to enable politicians to act up to the good old Roman proverb which begins, "*Si vis pacem*——," without thought of axes and other hindrances.

In a quiet underground Control Room sat an officer among the shaded electric lights. His country is in the midst of war, and he sits in the centre of the air-intelligence web. Round him, on tables or hanging on the walls, are numerous transparent maps, telephones and electrical instruments, including self-developing cinema films, a tape machine and a master clock.

A telephone tinkles and a spot of purple light appears on one of the maps. He dons a head receiver and a breast transmitter, to leave his hands free, and receives a message of warning from one of the very distant light-ships, which is indicated by the purple glow-lamp; the report is soon corroborated by wireless from one of those Policemen of the Seas, a Naval patrol. Certain land areas are at once warned by the officer on duty, to be ready for air-raid action. He also rouses an assistant by pressing a button at the edge of the table. Five minutes later two of the High Water Mark Sound Locator Stations report a "B" raid (*i.e.*, of two to five machines), probably Gothas or Aviatiks, flying in a S.W. direction. The initial warnings are flashed to their destinations and one of the maps of the Kingdom, divided into large areas by broad black lines, becomes suffused with the dull glow of small electric lamps. Some of the areas become red, others green. The first are those over which the

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raid will progress if it holds on its present course; the latter, surrounding the red, form a band of green areas which have received the first warning message for preparation. Naval Air Headquarters are busy obtaining all the information available to enable their fighters to sweep up the residue of the raiders when on their return home.

Soon a soft hum in the Control Room indicates that the films and tape machine have come automatically into operation, and are busy with their remorseless indications of the raiders' movements. His leading machine has arrived over the outer sensitive indicator line which follows the shore. A tiny white light has appeared at the coast of another map, and is soon followed by four others, which all move slowly inland. There are five machines in all. The uncoiling films and tape give the details necessary for the military defences, such as the exact height and speed at which each is flying, which, together with the make and size of the machine ascertained from the notes of their propellers, enable the probable object and tactics of the raid to be divined. Three heavy bombers protected by two fighters. Double how they may, the tell-tale spots of light, originated in sound vibration, follow with relentless certainty. The greens on the area map give place to reds, to be surrounded in turn by other greens further afield. The tape machine, meanwhile, has been recording every message sent to the Spider in the centre of his web, as he waits to pounce. These messages are from countless sources, observation cordon posts, county police stations, naval or military garrisons; but the gist of them all, when sifted and weighed, forms an ever-certain clue to the exact position and objects of the "flies," and as such is being transmitted to other offices.

At last they approach an active gun area. In certain battery and searchlight control rooms, five tiny dots of light on a similar squared map are approaching the defended circle: a tape machine gives the corroborated and digested details required to enable all concerned to take action, which is synchronized by the electric sub-clocks.

Space above the country-side is divided into great columns of invisible bricks, one and a half miles by one and three-quarters on the ground, while each of the bricks composing the column is a thousand feet high.

Suddenly one of the bricks, the tenth from the earth, becomes alive with bursting shell, while eighteen dazzling pencils of light pierce the heart of the column. A haze makes observation difficult at present, but provides the information that the objective of the raiders has not been reached, for visibility is as necessary to the fly as for the spider. Every defending searchlight is provided with a sound locator, which begins to indicate the direction of the target before it is within range. So that when the expectant beam is eventually uncovered it is already near the required line, and a few

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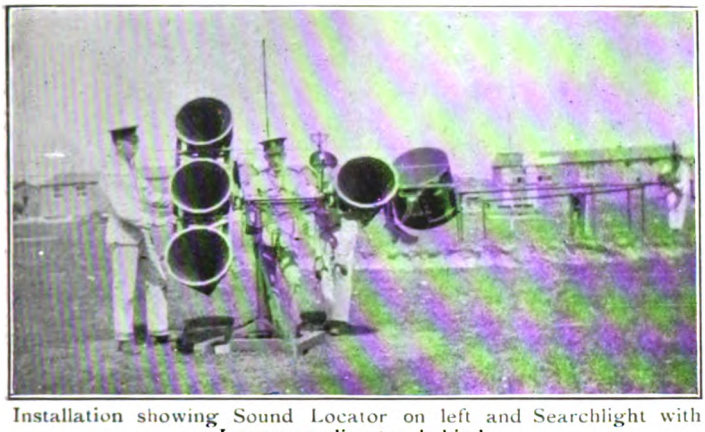
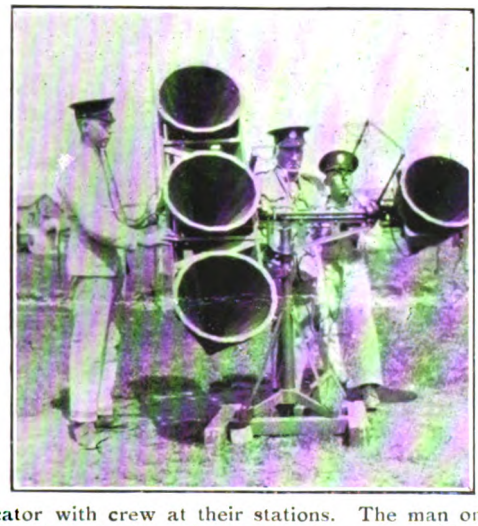
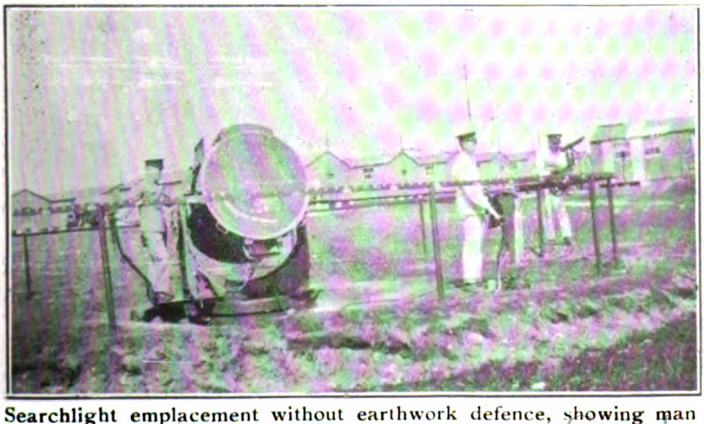
THE WAY OF AN EAGLE.



Installation showing Sound Locator on left and Searchlight with Long-arm director behind.



Sound Locator with crew at their stations. The man on the right directs by telephone the man on Long-arm of Light.



Searchlight emplacement without earthwork defence, showing man on Long-arm with telescope, who directs the beam.

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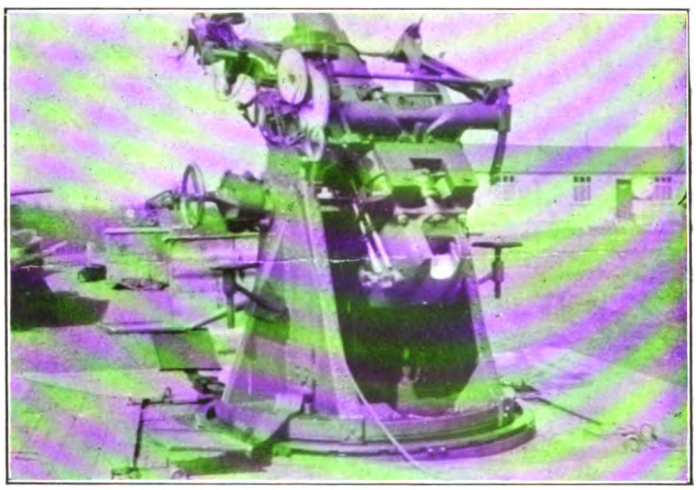
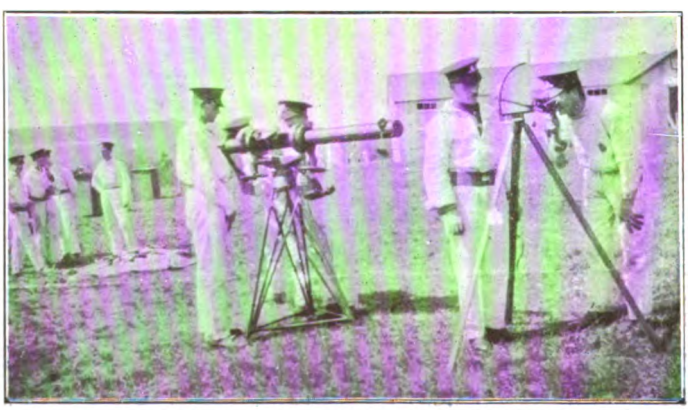
3″ A.A. Gun on Mobile Mounting.



3″ A.A. Gun on Semi-Fixed Mounting.



Left—Height Finder. Right—Height Fuze Indicator.

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CONTROL ROOM LONDON A.A. DEFENCES, DURING THE WAR.

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seconds' manœuvring suffices to correct it and make the target visible if atmospheric conditions permit.

At last, in a patch of clearer sky, the underside of an aeroplane is lighted up by a searchlight; instantly two other beams fasten on to the victim, and in the deadly triangle he is held while all the guns in the neighbourhood reach up and finally pull him down. He is one of the escort.

Now the raiders pass out of the turmoil of gun-fire into an area of peace and quiet, where their minds are vexed only by the waving pencils of light which seem always to work in threes. No gunfire! Now is the time to sink to bombing height so that they can see to make sure of the artery in the neck of the enemy which they have come to sever. They pay the penalty of descent by feeling the intangible lights fasten upon them from below. As each beam touches its target, two others immediately join it and all three cease their wavings and remain fixed with a nerve-shaking steadiness. Suddenly a crackle of machine-gun fire from below his tail, and one of the bombers goes nose-diving to earth; he has been attacked without chance of escape, by a Bristol fighter swooping out of the darkness. It is like firing at an illuminated ball in the booth of a country fair. The defending machines can remain in the darkness till they spot an illuminated enemy, when they know that the beams will keep steadily on it and not be a danger to themselves.

Soon the defending zone is crossed and the invaders are met with a second burst of gunfire. No. 2 bomber loses his nerve and feels that he has had enough of it, so he turns round, unloads his eggs and makes a bee-line for his happy home, climbing fast as he goes. But as he clears the outer gun zone and comes over the sensitive sound locators again, his direction, height and speed, indicated by the spot of light on the map, when read in conjunction with the record of the cinema film, tell their unmistakable story to the Spider in his control den, before even the tape-machine begins to corroborate. He makes a terse remark to his subordinate, who passes on the information to the waiting sea-planes which are now cruising at their " ceilings " far above the mist and clouds.

The third bomber gallantly dives for his objective, to be caught by the searching white beams and " archied " in mid career. There is nothing left for the survivor but to climb out of the inferno at top-speed and seek his way back by a devious route at his maximum height till he is clear of all entanglements.

I woke with a fresh problem in my mind. Can the hum of a propeller and the whine of the wind in the rigging be absorbed or covered up effectually by the scientific application of another purposely produced sound vibration, just as one muffles a loudly-ticking clock in a blanket? During the later phases of the last war our precious transports were escorted by destroyers through the

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dangerous waters. When a submarine attack was thought to be imminent, one destroyer often surrounded the transports with a smoke-ring, through which the assailant was unable to sight its weapon on the target. It should not be too difficult to produce a suitable mist in the atmosphere from kites or captive balloons, even over a large area, so as to cause the enemy to descend to dangerous heights before he can obtain reliable enough information by which to unload his bombs with any degree of accuracy. Gas-shell might produce a larger lethal space than explosives, but greater effect still would follow the discovery of a directional device for the projection of a ray of heat as one now projects light.

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EVERY-DAY MATHEMATICS FOR ENGINEERS.

A Lecture delivered at the S.M.E., Chatham, on February 15th, 1923, by LIEUT.-COLONEL G. H. ADDISON, C.M.G., D.S.O., R.E.

"Divine Mathematics, which alone can purge the intellect and fit the student for the acquirement of all knowledge."—*Roger Bacon*: 1250 A.D.

IT is customary for a lecturer to open with an apology for his unworthiness, followed by an explanation that he is actually much worthier than anyone else. In the present case both apology and explanation are precisely the same, and are simply that I am not a mathematician.

The peculiar psychology of the pure mathematician leads him to surround his trade with a fog of awe and mystery, by means of which he successfully disguises the fact that much of it is a very simple and ordinary business.

All through History one finds this atmosphere of black magic.

The earliest mathematical work, of which any copy exists, is a treatise by one Ahmes, an Egyptian, dating from, roughly, 2,000 B.C., and this bears the illuminating title "Directions for obtaining the knowledge of all Dark Things."

Pythagoras, the first of the great Greek mathematicians, some 1,500 years later founded a school, the members of which were sworn to the utmost secrecy in regard to their knowledge and discoveries.

There is no time for a history of mathematics, but few romances are more engrossing than the story of how the works of those wonderful old Greeks were preserved through the ages by the Arabs, and were brought by them to Spain in the X. and XI. centuries. There they were sedulously guarded by the Moslems from the eyes of Christians and other infidels; and it is recorded* that English men of learning underwent incredible dangers in the endeavour to get copies of these writings. One Adelhard of Bath is stated to have secured the first copy of Euclid after adventures that must have far surpassed those of any modern Bull-dog Drummond.

Later on, again, we find that all through the XVIII. century, English and Continental mathematicians were working apart, and jealously guarding their discoveries from each other on account of a petty quarrel as to whether Newton or Leibnitz was the true author of the Calculus.

* For this and other historical facts, see *A Short History of Mathematics*, by W. W. Rouse Ball. Macmillan & Co.

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Now the engineer has no use for black magic or mystery; he wants something that will help him to solve practical problems. I can imagine no better analogy than that which is always used by Professor Inglis; that of the "tin-opener." Doubtless, a tin may be opened without the use of an efficient tin-opener, but the result is generally to damage the fingers and to spoil the contents of the tin. So also an engineering problem may possibly be solved without the use of mathematics; but it is apt to be a laborious and ugly business, and very likely to end in a mess.

It is further true that nearly every branch of common mathematics has its origin in the need for some kind of "tin-opener." Geometry (γῆ—the earth, μετρέω—I measure) was first evolved by the Egyptians in the service of Land Surveying.

Aristotle was led to the study of the lever by noticing how much easier it was to have a tooth extracted by means of a pair of pincers than by the bare fingers.

Arithmetic grew up with the requirements of commerce and trade; this explains at once why a gentleman was never expected to have a mathematical education; a tradition which some of the great public schools and universities have scarcely yet succeeded in stamping out.

Tables, weights and measures are all derived from parts of the body, or from things in common use; *e.g.*, foot, digit, furlong (=furrow-long). The decimal system comes from the fact that there are five digits on the human hand; if we had been born with six, no doubt, the duo-decimal system would be universal. (It seems a pity that we were not !)

The primary unit of weight and measure has almost everywhere been the grain of barley. Such examples might be multiplied indefinitely.

Trigonometry arose from early efforts to study Astronomy.

The Integral Calculus has an interesting origin.* In 1612, there was a mammoth wine harvest in Germany, and no one could say whether the supply of casks would suffice to carry it. The question was referred to a great mathematician, Kepler, who had made a special study of areas contained by closed curves. He solved the problem for the wine-merchants, and subsequently produced a book, the title of which (in Latin) was "A New method of measuring Wine-Casks." This seems to contain the first mention of the Infinitesimal Calculus.

John Napier,† to whom mathematics were mainly a pastime, invented logarithms out of sheer horror at the waste of time involved in long and useless calculations. One of his contemporaries spent the whole of a 70 years' long life in working out the value of π correct to 35 places of decimals; as recently as 1873, one, William Shanks, worked it out to 70 places of decimals !

* See *Applied Calculus*, by F. F. P. Bisacre. Blackie.

† Napier was born about the middle of the XVI. century.

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Fortunately for the engineer, two places are generally ample for practical purposes, and these may be read off at once from a slide-rule, which is the natural offspring of Napier's invention.

I suppose that every modern engineer gets accustomed to use a slide-rule at a very early stage. Those who do not are merely choosing to remain in the XVI. century—a not exactly intelligent choice.

This question of degree of accuracy is a very important one, and one on which the engineer and the mathematician wholly part company. Time does not permit me to do more than draw attention to its importance, and to the fact that common-sense is chiefly required in dealing with it.

This virtue—common-sense—is also highly necessary in approaching the subjects of limiting values and infinite series, through which we are led to the Calculus. In the V. century, B.C., the philosopher Zeno suggested the problem of Achilles and the Tortoise, which so disturbed the mathematicians of that day, that for centuries the Greeks avoided any idea of an infinite series; in the XX. century, A.D., infinite series and limits are mere commonplaces; but what is to be said of a system that introduces new ideas to a youthful student in words such as these?—

3. *Definition of a Differential Coefficient.*

If fx denotes any function of a variable quantity x, and if $f(x+h)$ denotes the *same* function of $x+h$ when x receives a small *increment* h, then the *limiting value* of

$$\frac{f(x+h)-fx}{h}$$

when h is indefinitely diminished, is called the *differential coefficient* of fx with respect to x, and is denoted by

$$\frac{dfx}{dx} \text{ or } f'x.$$

This definition may be conveniently expressed as

$$\frac{dfx}{dx} = lt\ \frac{f(x+h)-fx}{h}$$

(lt) being the abbreviation employed to denote the limiting value, as h is indefinitely diminished and ultimately becomes zero.

Since $f(x+h)-fx$ is the increment of fx corresponding to the increment h of x, therefore

$$lt\ \frac{f(x+h)-fx}{h}$$

is the *ultimate ratio* of the corresponding increments of fx and x, denoted by dfx and dx, and called the *differentials* of fx and x; and thus $\frac{dfx}{dx}$ measures the *rate of increase* or *growth* of fx; while $\frac{f(x+h)-fx}{h}$ represents the *average* rate of increase of fx from x to $x+h$.

The chief object at the outset of our subject is the determination of the differential coefficients of functions, and the application of them to the discussion of the geometrical and analytical properties of the functions.

The algebraical difficulty in the determination of the differential coefficient lies in the reduction of its original *indeterminate form* $\frac{0}{0}$ to a determinate limit.

(Hall and Knight, *Higher Algebra*, chap. xx.)

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The name *derivative* or *derived function* is sometimes used instead of *differential coefficient*.

The differential coefficient $f'x$ of a function of fx may be supposed to derive its name from being the coefficient which turns the differential of x into the differential of fx.

(Wicksteed, *The Alphabet of Economic Science*, p. 32.)

This extract is taken from the opening pages of a work that was for years the standard text-book at many universities and public schools, and also at the R.M. Academy. The last paragraph is peculiarly inspiring, and the oftener I read it the easier I find it to realize why it took me thirty years to understand that there could be any possible use in a differential coefficient.

And yet, of all branches of mathematics, the Calculus is surely the most essential in the fashioning of our tin-opener.

In physical problems we are continually dealing with quantities that are varying in such a way that any change in one of them produces a corresponding change in the other or others. Many simple cases may be—and very frequently are—solved by graphical methods; but these are usually slow, and the accuracy of a solution depends upon the very variable personal equation of the draughtsman. One may take a mean, or average, value; this is aptly described by the French as being the certain method of getting an inaccurate answer. The only perfectly general method of attacking such problems is by means of the Calculus, and it was invented by Newton for that purpose.

Let me take a very simple case: the statement of Newton's 2nd Law of Motion, which may be analysed in either of the two ways following:—

$$P = M\,a$$

$$P = M\frac{dv}{dt} \quad \text{.....(i)} \qquad \Big| \qquad P = M\frac{ds}{dt}\cdot\frac{dv}{ds}$$

$$= Mv\cdot\frac{dv}{ds} \quad \text{.....(ii)}$$

whence, integrating between values $v=v_1$ and $v=v_2$,

$$P\times t = Mv_2 - Mv_1 \qquad \Big| \qquad P\times s = \tfrac{1}{2}\,Mv_2^2 - \tfrac{1}{2}\,Mv_1^2,$$

or, put into words:—The time effect of a force is to produce change of momentum, while the space effect is to produce change of kinetic energy.

Equations (i) and (ii) are termed "differential equations," and many will be met with in engineering problems that are little, if any, more alarming than these two. Certain standard tricks have to be learnt, and by their means the solutions of all ordinary equations that arise out of practical work can be written down.

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I choose this particular example because it has a tale attached to it.* Rather more than two hundred years ago, a bitter quarrel began as to whether the "force of a body in motion," as it used to be expressed, should be measured by the product Mass × Velocity, or Mass × (Velocity)^2. England asserted the former; Germany, supported by Holland and Italy, the latter; France was divided. The whole of Europe was shaken by the struggle for 40 years, during which rival mathematicians set each other an endless series of problems, but always with the result that both sides got the same answer. Finally a Frenchman proved that they were, in fact, both right. One party had measured the effect over an interval of time, the other over a distance, and the whole trouble was one of phraseology.

This question of phraseology has a very important bearing on our subject; witness the extract given earlier. A good example of the devastating influence of bad phraseology is the following:—It is stated† that the Ancos, a race on the River Amazon, cannot count beyond three, since the simplest word they can find for three is "Poettarrarorincoaroac."

An illustration of a similiar kind to my first may be met with in the study of Thermo-dynamics.

In any reversible change, when the working substance does work, we have the simple relation:

$$\delta Q = \delta E + p\,\delta v,$$

which is merely a statement of the general principle of the Conservation of Energy. A little easy algebra and heat theory combined lead to:—

$$\delta Q = C_v\,\delta\tau + p\,\delta v \qquad C_v = \text{specific heat (constant volume)}$$

$$\frac{\delta Q}{\tau} = C_v\frac{\delta\tau}{\tau} + \frac{p\,\delta v}{\tau} \qquad pv = R\tau$$

$$\therefore \frac{p}{\tau} = \frac{R}{v}$$

$$= C_v\frac{\delta\tau}{\tau} + R\frac{\delta v}{v}$$

$$= C_v\,\delta(\log_e\tau) + R\,\delta(\log_e v)$$

$$= \delta(C_v\log_e\tau + R\log_e v)$$

$$= \delta\phi.$$

* See *Elementary Rigid Dynamics*, by E. J. Routh. Macmillan & Co. (*Note.*—This book is by no means elementary. The title may be designed to suggest that the author knew a great deal more than is actually printed).

† *History of Elementary Mathematics*, by F. Cajori. Macmillan & Co.

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The last expression in brackets tells us something about the "state" of the working substance; it is what the mathematician calls a "function" of the state. Now experience shows that this function can be made use of in all sorts of ways; and so, instead of the cumbrous expression in brackets, it is written as ϕ, and given the name "Entropy." There cannot be much difficulty in following this. But the academic mind loves to introduce Entropy as a special brand of the black art; and it is usually done in the following form:—

"*Definition*: If a body A at temperature (absolute) τ gives out to another body B, also at temperature (absolute) τ, a quantity of heat defined by Q, then A is said to lose entropy $\frac{Q}{\tau}$ and B is said to gain entropy $\frac{Q}{\tau}$."

This almost certainly produces a state of mental confusion, for it suggests the idea that entropy is something concrete instead of being a mere mathematical function. A young officer complained to me once that nobody had ever succeeded in explaining to him the meaning of entropy or of $\sqrt{-1}$. I could not help suspecting that, in the case of entropy, this failure was due to a fixed belief that it was something that could be poured out of a can!

$\sqrt{-1}$ receives very ponderous treatment in most text-books, under the heading of "Unreal Quantities." Now it may be unreal to the mathematical mind, but, if it is to be of any kind of use to the Engineer, it has got to become real, and without its aid a blunt spot will be left on the tin-opener. The Engineer writes "i," or in electrical work "j," which is both real and simple.

A very common case, in which it turns up, will be quoted.

An ordinary vibration, or "Simple Harmonic Motion," as it is called (such as the motion of a pendulum, or of a weight hanging from a spring) is distinguished by the fact that acceleration is always proportional to displacement; so the equation of motion may be written:—

$$\frac{d^2x}{dt^2} = -\mu x \qquad \text{(notice the sign).}$$

or

$$\frac{d^2x}{dt^2} + \mu x = 0,$$

or, in a more convenient form

$$\frac{d^2x}{dt^2} + p^2x = 0.$$

This is solved by substituting $x = e^{mt}$,

whence $m^2 + p^2 = 0$, or $m = \pm ip$,

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and the whole solution is

$$x = Ae^{ip} + Be^{-ip}.$$

If the expressions for sin x and cos x* are known it will be easily realized that the solution can be written in the more useful form

$$x = P \sin pt + Q \cos pt.$$

This gives all possible information about the motion. Most practical cases are such that the motion starts from rest, when one term disappears we have $x = Q \cos pt$ simply.

Now suppose that, tending to check or " damp " the motion, there is some kind of friction which is proportional to the velocity; the equation becomes

$$\frac{d^2x}{dt^2} + q\frac{dx}{dt} + p^2x = 0,$$

and, going one step further, let the point of support of the spring or pendulum be given a " forced " motion of simple harmonic nature; then the right-hand side of the equation, instead of being 0, takes the form $Q \cos pt$, and the whole equation, by a little simple algebraical juggling, may be written

$$A\frac{d^2x}{dt^2} + B\frac{dx}{dt} + Cx = Q \cos pt.$$

This has a stodgy look, but again, if the trick is known, the whole solution can be written down at sight. If the trick is not known (and obviously there is no time this afternoon to teach tricks), this statement and what follows must be taken on trust. If the simple vibration with which we started is one that occurs n_0 times per second and the forced vibration given to the point of attachment occurs n times per second, then after the damping effect has died away (which it does very soon in practical problems) the final steady motion is given by

$$x = \frac{Q \cos 2\pi nt}{4\pi^2(n_0^2 - n^2)}.$$

This shows that, if n_0 and n are nearly equal, x becomes nearly equal to infinity, which means that the motion becomes enormously magnified. This is the condition usually known as " resonance," and its importance can hardly be over-emphasized. It is probably at the bottom of most structual failures and accidents in the past, which at the time, seemed unaccountable.

Modern " wireless " depends completely on it; the rolling of a

* $\sin x = \frac{e^{ix} - e^{-ix}}{2i}$; $\cos x = \frac{e^{ix} + e^{-ix}}{2}$.

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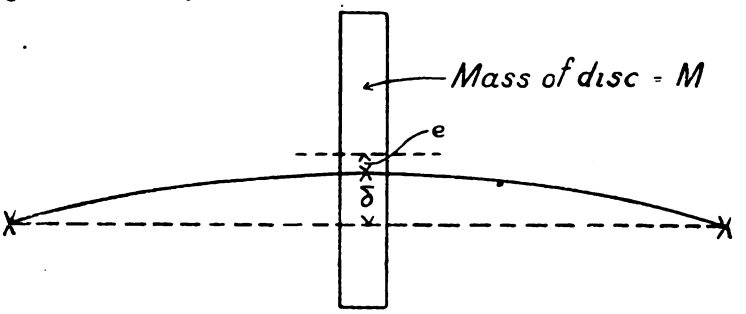
ship at sea; the danger of marching across a suspension bridge without breaking step; these are some of the innumerable examples that might be quoted.

But without mathematics I do not think this subject can be studied or understood in the slightest degree.

The phenomenon known as the "whirling" of a shaft provides a simple and instructive example of a similar kind.

*Suppose we have a disc fitted on a long slender shaft, which is rotating freely in bearings. It is well known that the disc does not remain concentric with the shaft, nor does the shaft remain quite straight.



Let the centre of gravity of the disc be e distant from the shaft, and let the shaft bulge an amount δ.

Then the centrifugal force required to maintain an angular velocity w is

$$M(\delta+e)\,w^2.$$

This is supplied by the whippiness of the shaft, and the equation of motion may be written

$$M(\delta+e)\,w^2=K\delta,$$

where K is some factor depending on the physical properties of the shaft,

$$\delta\,(K-Mw^2)=Me\,w^2.$$

$$\therefore \quad \delta=\frac{Me\,w^2}{K-Mw^2},$$

then if $K-Mw^2=0$, or $w=\sqrt{\frac{K}{M}}$, δ tends to become infinite;

* This example was suggested to me by Professor C. E. Inglis, to whom I owe a deep debt of gratitude for much other help in the preparation of this paper. Any small knowledge, and all the great enjoyment that I have gained in the study of practical mathematics are unreservedly due to Professor Inglis and the Staff of the Engineering Laboratory, Cambridge.

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that is to say "whirling" occurs. After this critical value is passed, and w grows larger, δ becomes negative; and when w is very large indeed, δ becomes approximately equal to $-e$.

This theory controls design in modern high-speed work; such as, for instance, the Laval Turbine. It shows that speed must be run up through a definite "critical" value before the load is put on; and, secondly, that the shaft must be "whippy": such shafts are, in fact, made as whippy as possible, consistent with the horse-power they have to transmit; a result that would be difficult to anticipate without the aid of mathematics.

These are just a few examples that are typical of the sort of every-day work that confronts an engineer; and I hope it will be agreed that there is nothing very terrible in the mathematics that are needed to deal with them. Certainly there is nothing that is not well within the powers of anybody who has achieved a commission in the Royal Engineers.

Mercifully it is no longer necessary to struggle through intellectual sloughs of despond such as I referred to earlier; there is a large and ever-growing number of text-books written by and for practical men, and they are at the disposal of all who care to study them.

I have spent a considerable time in abuse of mathematicians. The remainder of this lecture shall be devoted to reminding you of a few of the wonderful things that mathematicians have actually done for engineering. And let me say at once that, if our subject this evening was the contributions made by Engineering to the advancement of pure Mathematics, there would be nothing more to say; for the balance is all on one side.

I have already referred to wireless telegraphy. Sixty years ago Clerk-Maxwell produced the electro-magnetic theory of light, and worked out mathematical equations which still remain the last word in wireless theory; these also form the pivot of the whole of the modern mathematical theory of the Universe: the commonly called Einstein theory. It remained for engineers to discover practical means of using Clerk-Maxwell's work; and, as is well known, it took them a considerable time.

The Michell thrust-block is a classic example of its kind. A thrust-block provides the connecting link between the body of a ship and its engines. Everyone knows what a troublesome thing a bearing can be, even in small engines; when one is dealing with the transmission of huge horse-power, such as that required for a fast cruiser, the difficulties are enormous, and, before Michell's invention, the thrust-block was one of the most involved, bulky and expensive parts of a ship's mechanism. Everyone knows, too, that the laws of solid and of fluid friction are diametrically opposed; whilst those of friction between two surfaces, separated by a film of lubricant, are different from either, and are of an involved character.

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A very great mathematician and engineer, Osborne Reynolds, worked out the mathematical theory of lubrication* a good many years ago; but not in a form that made it immediately applicable to practice. An Australian consulting engineer, Michell, extended this theory, and succeeded in working out the exact mathematical relations for a film of lubricant in use under practical conditions.† He arrived at perfectly amazing results; but, when tested in practice, they were found to be completely confirmed. It is impossible for me to attempt any description of the theory, but some of the practical effects may be of interest.

The oil film acts like a ball-bearing, and was found to reduce friction to 1/20th of that in a flat thrust.

The old-fashioned multi-collar horse-shoe type for one class of battleship was 25 feet long; the Michell block that replaced it is 7 ft. long, and just one-third of the weight.

The old type could only be designed to transmit pressures of 20–50 lbs./sq. inch; the Michell block transmits 200–300 lbs./sq. inch. Another feature is that, before the advent of the Michell block, it was impossible to know the actual thrust produced in a ship. At first it was only feasible to specify "indicated" horse-power; later the Thring-Hopkinson torsion meter made it possible to measure shaft horse-power; but, with the Michell block in use, it is quite simple to measure the actual thrust. As an example of a recent test:—The 37,000 horse-power engines of H.M.S. *Hood* were found to give a dead thrust of 100 tons.‡ The possible applications of pressure film oil lubrication must be almost limitless and one may expect in time a revolution in thrust and journal bearing design. I have already heard§ of a motor car in which the piston transmits thrust direct, without the intervention of any connecting rod.

A very well-known mathematical triumph is in connection with the submarine telegraph cable. I believe that the first cable that was laid failed to give any result, and the whole question was put before that great man, Lord Kelvin. He reduced it to a mathematical equation and showed how to find solutions for any given conditions. As a result, before the Atlantic cable was laid, it was known exactly how long it would take a signal to get across, and how much its intensity would be reduced in the passage. Endless time and huge sums of money must have been saved by Lord Kelvin's work.

A most interesting case, in which the mathematician and the

* For a summary of this, see *Engineering*. July–December, 1915.

† See *Engineering*. January–June, 1920. Also *Proc. of Inst. of Naval Architects*. April, 1919.

‡ These figures were given me by Mr. T. C. Wyatt, Fellow of Christ's College, Cambridge.

§ Also from Mr. Wyatt.

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engineer together succeeded where mathematics alone had failed, is provided by the work of Messrs. Griffith and Taylor in solving torsion problems by the use of soap films.* Anyone who has studied the mathematical theory of elasticity knows that, when an elastic bar of uniform cross-section is twisted, the equations representing the stresses that are set up can only be solved in the case of a very few simple sections. Now in aircraft design many parts, such as, for example, airscrew blades, have a very complex section ; and there is no known mathematical means of finding either the stresses or the torsional stiffness. By what seems a freak of coincidence, however, the torsion equation of an elastic bar has precisely the same form as the equation representing the displacement of a soap film, due to a slight pressure acting on its surface, the film being stretched across a hole in a flat plate of the same shape as the cross-section of the bar. Mr. G. I. Taylor, a Cambridge mathematician, who was working at the Farnborough Aircraft Factory during the war, followed this up, and showed that the curvature of the soap bubble would represent the rate of variation of shear stress in the section, and that the volume of the bubble would give the total torque required for a given twist. Mr. A. A. Griffith, an engineer working at the R.A.F., designed a very simple apparatus for producing and measuring the soap bubbles ; and together they investigated a large variety of cases, from which they were able to enunciate various new theorems of great practical interest and value. Comparison with direct torsion experiments showed that the percentage error in the soap film measurements was very small, and well within practical requirements. By plotting the contours of the bubble the stress distribution is illustrated graphically. Mr. Taylor very kindly gave me permission to reproduce an example, which represents the section of a wooden aeroplane wing spar. The picture brings out clearly one of the new theorems which resulted from the work. It is that the maximum stress occurs at or near the points of contact of the largest inscribed circle, while there is an unstressed fibre at or about the centre of that circle. The simplicity of the apparatus has to be seen to be believed, and it can, of course, be used with equal facility for the most complicated and irregular sections. I find it difficult to explain why this method has not received more universal appreciation. Probably it is due to the comparatively limited number of structural problems in which it is required ; it is also true that mathematicians have lately been succeeding in finding solutions of equations which had previously defeated them. I believe that Messrs. Griffith and Taylor have further developed the method to deal with the shear stresses due to bending.

* See *Proc. of Inst. of Mech. Eng.* December, 1917.

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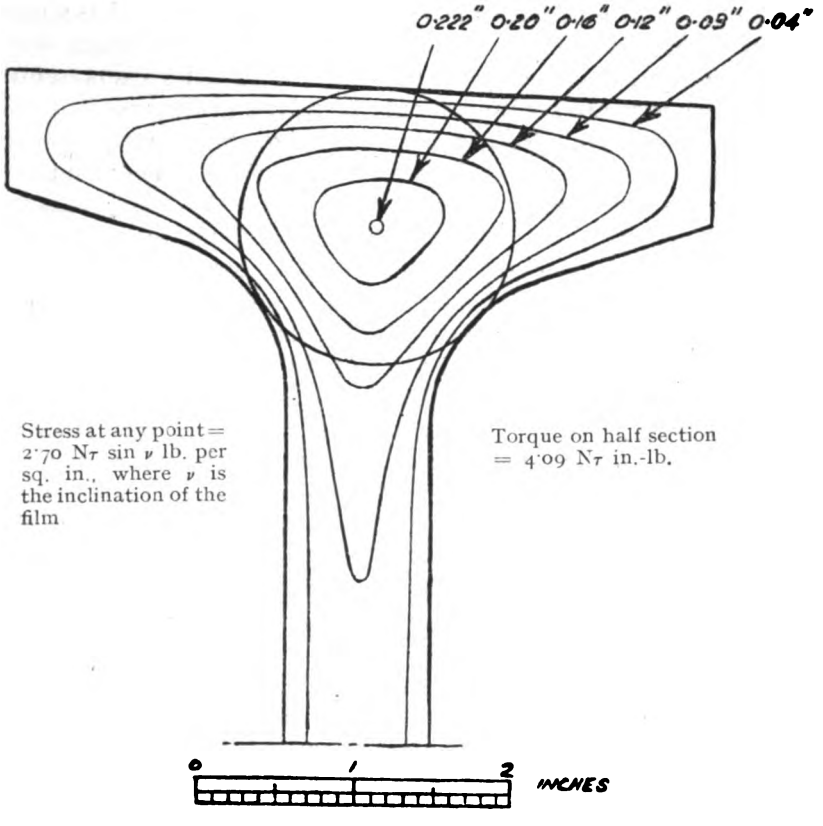
Lines of Shearing Stress in the Torsion of a Wooden Spar to scale.
The figures give the heights of the contour-lines of the corresponding soap film.


0·222" 0·20" 0·16" 0·12" 0·09" 0·04"
Stress at any point = 2·70 N$_T$ sin ν lb. per sq. in., where ν is the inclination of the film
Torque on half section = 4·09 N$_T$ in.-lb.
0
1
2
INCHES

My final example is concerned with work that is actually in progress at the present time. A subject that has always worried engineers is the exact nature of the stresses set up in a railway bridge by loads moving across it. The problem is a very complex one, and is closely connected with that of "forced vibrations," which I spoke of earlier; but it is extraordinarily difficult to find out anything definite about these vibrations. In old days a new bridge was tested by noting its deflection under load; a very incomplete test, but the best that could be devised. Recently meters have been perfected by means of which the actual strains in the various bridge members are registered. This is a great advance, and, by taking enough observations under varying conditions, it should be possible to arrive at useful conclusions. But such practical investigation, unsupported by theory, is a kind of groping in the dark, and can only lead to empirical formulæ, which may or may not prove to be what are really wanted. If mathematical confirmation can be provided, then the results become conclusive. This mathematical work is being done at Cambridge, where the same problem was

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attacked seventy-five years ago* by a very famous mathematician, Professor (later Sir George) Stokes. His problem took into account the mass of the moving load, but not of the girders; consequently his results had little or no bearing on the practical problem, where the mass of the girder may be as large as, or even larger than, the mass of the moving load. Stokes noted the weakness of his method in several respects, but does not appear to have carried the investigation further. Professor Inglis started by making similar assumptions,† the reason being that this enabled a differential equation to be written down without great difficulty. But he has gradually realized that a closer connection with reality is obtained by considering the girder to have mass, but the advancing load to exert a steady downward force on the bridge; or, in the case of the driving-wheels of a locomotive, a pulsating force. The reason for this is that the bulk of the mass of the train is spring-borne.

Working on these lines, good progress has been made, and finite conclusions, which are not too complicated to cope with, have been arrived at.

There are really two distinct problems involved; the effect of the moving load, and the impact effect. The first one is finished, and Professor Inglis has most kindly given me the accompanying graphs (see *Plate* on p. 92), which show that, given perfectly smooth running, the effect of the moving load is scarcely different from that of a statical load. Smoothness of running is, of course, never completely attainable, but it varies greatly under different conditions; *e.g.*, the movement of an electric engine is far smoother than that of a steam locomotive, in which the balance weights and other causes produce a considerable impact effect. The impact problem is not yet finished, but enough has been done to prove how highly unsatisfactory is the custom of multiplying by a fixed "live load" factor.

It may interest experts to know that the whole mathematical mystery is locked up in a partial differential equation of the form:—

$$\frac{\partial^4 y}{\partial x^4}+K^2\frac{\partial^2 y}{\partial t^2}=0, \text{ where } K=\sqrt{\frac{m}{EI}},$$

subject to 1 shear and 4 end conditions.

Perhaps it is hardly necessary for me to say that this class of mathematics does not come within the "every-day" category;

* This was about the time when the Britannia tubular bridge over the Menai Straits was being built. Theoretical knowledge was extremely hazy, and this great bridge was designed in accordance with experiments made on models, which were tested to destruction.

† He had not heard of Stokes' work until he had completed his own and realized its failings. In looking for confirmation of his own solution of an involved equation he found a reference to a paper by Stokes, in which exactly the same solution was arrived at.

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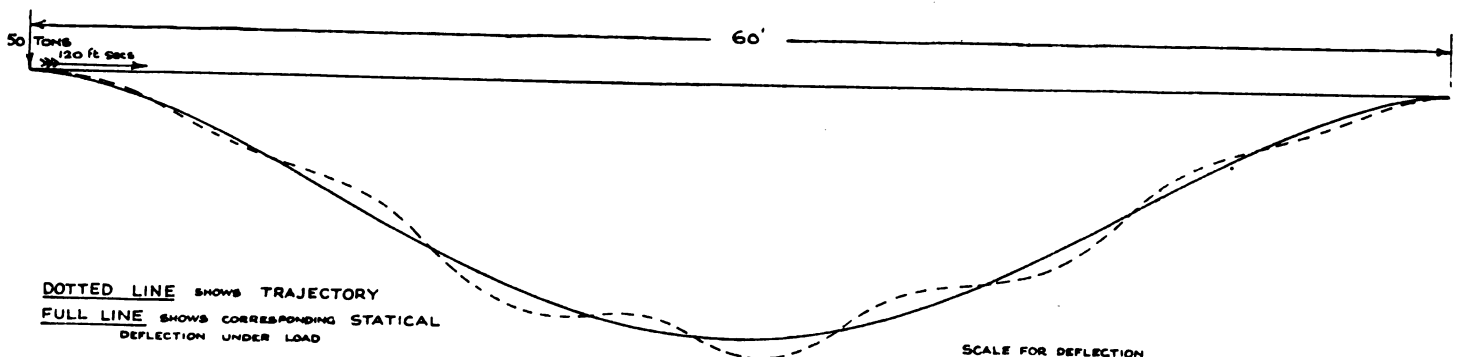
TRAJECTORY OF MOVING LOAD

FOR A BRIDGE OF 60' SPAN
TRAVERSED BY 50 TONS
AT A UNIFORM SPEED OF 120 FT. SECS



PARTICULARS OF BRIDGE

PLATE GIRDER DESIGNED FOR 100 TONS LIVE LOAD, ∴ LOAD ON EACH GIRDER = 50 TONS
SPAN = 60 FEET
DEPTH OF GIRDER = 6 FEET
WEIGHT OF EACH GIRDER = 500 LBS. PER FOOT. (INCLUDING WEIGHT OF DECKING)
MOMENT OF INERTIA OF CROSS SECTION = 2 FT.^{4}

GENERAL EQUATION FOR FORM OF BEAM AT ANY INSTANT :-

$$\frac{d^4y}{dx^4} + K^2 \frac{d^2y}{dt^2} = 0 \quad \text{WHERE } K^2 = \frac{m}{EI}$$

CONDITIONS :-

$y = 0$ AND $\frac{d^2y}{dx^2} = 0$ AT BOTH ENDS, AND UNDER THE LOAD $y, \frac{dy}{dx}, \frac{d^2y}{dx^2}$ ARE CONTINUOUS BUT $\frac{d^3y}{dx^3}$ HAS A DISCONTINUITY DUE TO THE SUDDEN CHANGE IN SHEAR.

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nor can such equations be manipulated by a tin-opener. Professor Inglis, for all his light-hearted talk of tin-openers, is a mathematician of a very high order.*

The last equation was quoted in order to provide the mathematicians among my audience with some of the mental stimulus, which I fear may have been lacking in the lecture. For the rest of us I think the moral is that the Engineers' every-day type of mathematics has got more than one aspect to it. Besides enabling us to handle ordinary problems for ourselves, it has got to provide us with the knowledge to recognize our own limitations, and the wit to make use of the extended powers of others.

When old Euclid was Professor of Mathematics at the University of Alexandria, he was one day asked by a pupil who was just starting Geometry: "What do I gain by learning all this stuff?" Euclid summoned a slave, and said: "Give the lad some coppers, since he should make a profit out of what he learns." Let me remind you that all of us, as officers of the Royal Engineers, receive a number of coppers in return for stuff we are expected to have learnt. I am convinced that without mathematics we can neither earn those coppers, nor be worthy of the honourable title of Engineer.

* I ought to add that every one of the great men quoted in these examples was a member of Cambridge University. Ever since the days of Newton, Cambridge has led the world in the advancement of mathematical and physical sciences.

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A GLIMPSE AT THE MACHINERY OF REVOLUTION.

By CAPT. L. CHENEVIX-TRENCH, C.M.G., D.S.O., R.E.

WE in England fortunately know very little of revolutions and how they are managed; it may, therefore, be interesting to look a little behind the scenes, at the events which culminated in the German revolution of the 9th of November, 1918.

Before there can be a revolution, the masses of the people must, by some means or another, be brought to the right frame of mind.

In Germany the numbers of people who voted for Socialist candidates for the Reichstag had risen from 352,000 in 1874 to 4¼ million in 1911, and in 1914 there were over 100 Socialist deputies.

On the 5th August, the day before the Reichstag assembled to vote war credits, the German Social Democratic party met to decide what policy it should follow, and by 78 votes to 14 decided to agree to the credits.

Scheidemann headed the majority, and Karl Liebknecht the minority. From this date the majority Socialists were absorbed in the war-party, and Liebknecht and his handful of followers constituted practically the only anti-war influence in the whole Empire. For war itself they had but little hatred; they opposed it mainly because the government and all their political enemies supported it; and some of them probably even welcomed it for the opportunities it might be expected to bring to upset the existing order of things.

In all belligerent countries much the same split between patriotic and revolutionary Socialists occurred and in every one of them the latter were at first heavily defeated. Karl Liebknecht followed in the footsteps of his father Wilhelm in 1870 and, like him, voted against war credits and raised the cry of "peace without annexations or indemnities."

During the latter part of August he attempted to raise some peace meetings, but was dissuaded therefrom by his friends, who thought that, in the then state of public opinion in Germany, he would probably be lynched. He did, however, again cast his vote against the second war credit on 2nd December, 1914. His speech for that occasion was refused admission to the Reichstag records, but a few hundred copies of it were privately circulated. It was shortly after this that he, Franz Mehring and Rosa Luxembourg sent their New Year's greeting to the London "Labour Leader," apologizing for the part played by the German majority Socialists. The latter retorted by solemnly censuring Liebknecht and his followers for their attitude.

Growing bolder, Liebknecht made a speech at New-Kölln,

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advocating the class war not after, but during, the great war. Two months later his speech was reproduced and circulated, with the result that he was conscripted for the Landsturm Ordnance Corps, while his most active colleague, " Red Rosa," was imprisoned, and Franz Mehring's newly founded paper, *The International*, was suppressed. This firm action by the Government had a very damping effect on the revolutionary movement, which was not yet strong enough to stand many such shocks.

Rosa, however, managed to smuggle out of prison a number of articles which were entitled " Letters of Junius." These were fairly widely circulated both in Germany and abroad, and served to keep things going.

In reading these letters one cannot help being struck by the great difference in quality between them and our own home-grown stuff, such as appears in the *Communist* and similar publications. The German writings strike a much higher note than our own. Though " loot " and " something for nothing " is the ultimate aim of both, in the former this aim is very skilfully concealed by appeals to the intellect, which would have but little effect on the British Reds.

Rosa's arrest was due to the way in which she accused the authorities of conniving at brutality to recruits, and it is said that she had over 900 men prepared to vouch for over 40,000 specific acts of ill-treatment. The Government rightly considered her a very dangerous person, for, though her appearance was perhaps not of much assistance to her, she had a power of speech which could, in a few moments, whip up her audiences to frenzy. During most of 1915 Liebknecht's military duties kept him fairly quiet, though he did manage to speak occasionally in the Reichstag, and certainly once at an open-air meeting. Early in 1916, however, there began to appear, at intervals of two or three weeks, a series of letters over the signature " Spartakus." These were usually inspired, if not actually written, by Rosa and Liebknecht.

On the 13th January the Majority Socialists formally expelled Liebknecht from the party, thus providing further evidence of the perhaps not unfortunate split, which exists between the Socialists and Communists. Nevertheless he continued to speak in the Reichstag, in and out of season, and seems to have been allowed a wonderful latitude before being called to order. On the 1st May, 1916, being Labour Day, Liebknecht addressed a mass meeting in Berlin. His speech had been previously printed and circulated, and it is curious that the authorities allowed the meeting to take place. At its conclusion, however, he was at once arrested, tried, and sentenced to two and a half years' penal servitude. On appeal the sentence was increased to four years and one month, together with six years' loss of civil rights. On June 28th, as a result of the circulation of his speech in his defence, and of the publication of

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his sentence, a strike of 55,000 munition workers took place in Berlin, and others in the country.

These strikes were repressed by the authorities without much severity, and a few of the revolutionary leaders were taken for military service. This, combined with the loss of Liebknecht, sufficed to keep the movement quiet for the rest of 1916, which was devoted to propaganda.

The rather primitive duplicating methods hitherto used were found unequal to the growing demand for literature, and a regularly printed journal entitled *Spartakus* was now widely circulated.

The Russian revolution of the spring of 1917, though not nearly thorough enough for the German Independent Socialists, as Liebknecht's party was called, was of great value to them, to be held up as an example of what could be done. The numerous extreme left groups, which had been forming all over the country, began to draw more together and a feeling of some confidence was engendered which found expression in quite a number of strikes.

One of the largest of these, in April, 1917, was a protest against the reduction of the bread ration. Government, however, succeeded in putting down the trouble without very much difficulty, and once more the movement was driven underground. The Revolutionaries now directed their efforts still more to propaganda, and claim that as a result of this the value of the two youngest recruit classes was very much diminished.

Strikes organized for the 2nd September, 1917, were, nevertheless, almost complete fiascos, partly, probably, because of counter-propaganda issued by the Government throughout the factories and workshops.

The next impetus which the movement received was through the success of Lenin and Trotski in November, 1917. Though Ludendorff has declared that the dispatch of these men to Russia was a matter with which he and Hindenburg had nothing to do, its effects on the German army were most serious, and numbers of men, infected with the virus of Communism, penetrated into the country from Russia.

At the end of January, 1918, the Independent Socialists felt themselves strong enough to arrange for a big strike as an echo of those which had taken place in Austria, a fortnight before. The notices calling the strike were issued in the name of the "Executive Committee of Workers' Councils," of which we now hear for the first time. As showing how good their organization was, it is worth noting that the notices calling the strike for the 28th January were not issued till the 27th.

Some of the Committee wanted to issue the notices on the 24th, but were over-ruled, because the Government might thus have time to prepare counter-measures. This strike was a great success;

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over a million workers came out, 600,000 of them in and about Berlin. It was planned to last three days, but went on for a week. A good deal of rioting took place and many people were killed. Among the 40,000 men and women arrested was Kurt Eisner, who subsequently became Minister-President of Bavaria.

In April, 1918, the Government took advantage of the military successes in France, to reduce the bread ration and postpone the Prussian electoral reform bill. These measures were not actively resisted, except by pamphlets, which now appeared in ever-increasing numbers. The troops, particularly those on the lines of communication, were specially catered for, the literature intended for their perusal being on a much lower level than that issued in other directions. The officers were held up to ridicule and contempt, and equal pay, food and accommodation were demanded for all ranks. This pamphleteering continued till the final break-down and, reinforced as it was during 1917 and 1918 by propaganda from abroad, undoubtedly contributed very largely to the formation of a public opinion suitable for the action of the actual revolutionary executive committee.

This committee came into being on the 9th February, 1918. On that date the U.S.P. (Unabhängige-Sozialisten-Partei) lost its leader, Richard Müller, by arrest. The committee asked Emil Barth to take his place, and he consented to do so on his own terms, which were as follows :—

The committee was to call itself the " Revolutionary Committee " and to act up to its name. The party was to aim at Revolution. It was to be under his unquestioned leadership, with all subordinate leaders nominated from above, and not elected from below. The strictest secrecy was to be maintained as to the existence of the central committee, which would deal almost solely with the main question of when the revolution should be attempted. All other business was to be carried out by sub-committees, each so organized that no one man could give away more than a small amount of information to the authorities.

Some of the subjects with which these committees were to deal were :—

Money ;
Arms and ammunition ;
Intelligence about the enemy, under which heading police, troops and the Majority Socialists were grouped ;
" Storm-troops " ;
Supervision of their own comrades ;
Labour, etc., unions, and so on.

The sub-committees were to meet once a week and were to keep touch with the factories and workshops by means of men nominated,

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not elected, to represent them. Barth demanded unhesitating self-sacrifice from the leaders, as the only thing which could justify their demanding it from the rank and file, and finally declared that he would accept the leadership if unanimously elected.

The vote was then taken, and 17 of the 18 cards were marked with his name. The eighteenth card was unmarked, but one member, Heinrich Maltzahn, appeared no more at the committee meetings and Barth accordingly took the lead. His first steps were to get his organization perfected, and in this he met great difficulties.

In consequence of the January strikes the Government was very active, and reports spoke of little but arrests and courts-martial. So much repression was carried out that at one time it looked as if the movement was going to break down again, but, driven forward by Barth, as soon as limbs were cut off they were pushed out again, and the organization gradually rendered almost invulnerable.

Much of his energy had to be devoted to heading off the "Spartakists," who believed in demonstrations likely to provoke repression. Barth did not agree with this sort of action, which, he said, only resulted in the loss by arrest of the most active and energetic of his men. He believed in thorough preparation and organization, careful choice of opportunity, and one single and vigorous stroke. Jogisches, the then leader of the Spartakists, had many a conference with him, but though they never actually quarrelled, they could not come to any agreement.

As an example of the order which was growing up in the organization it may be mentioned that a regular scale of separation allowances was laid down for the families of men in prison. A wife got 25 marks a week with 5 marks for each child, and 30 marks a month as lodging allowance.

In April, 1918, some of the more hot-headed of his followers thought that a good moment had arrived, but Barth would not allow any move. They must wait, he said, till defeat had loosened the discipline of the army, and then strike their blow before the defeated and disorganized troops had had time to flood the country. He foresaw that, in the latter event, any government which might be formed, would only survive a very short time.

Some difficulty was met with in the provision of arms, and his reports complain of the profiteering prices which had to be paid for them. Hand grenades, too, were hard to come by, but money overcame all difficulties and soon a good stock of weapons was built up. There seems always to have been plenty of money, and though its source is not disclosed, there can be little doubt as to where it came from. Treasurers were generally very honest, for though the funds were kept under various names in different banks, they were never mis-applied. The formation of so-called "Storm-troops" was a most dangerous task. It began in August, 1918, after the

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failure of the July offensive in Champagne. One at least had to be formed in every big factory, and it was only the knowledge that the extreme penalty for any indiscretion would be exacted, by the Committee if not by the Government, that kept their existence a secret. The Majority Socialist in this, as in many other matters, constituted the greatest danger to the Revolutionaries. The blow dealt by the British Army on the 8th August showed that Barth's time was drawing near, and he stiffened up his organization till, by the time the Reichstag re-assembled on the 22nd October, he was ready for anything.

The Spartakists arranged a demonstration for this day. At first he would have nothing to do with it, but subsequently, in order to keep control as far as possible in his own hands, withdrew his opposition and ordered a few factories to take part. Only about 8,000 men came out and, after a few brushes with the police, dispersed quietly when Barth passed the word for them to do so. As a result of this demonstration, Liebknecht was released from gaol, whereupon another took place, about 20,000 strikers joining in and drawing Liebknecht through the streets of Berlin in a carriage filled with flowers.

When he and Barth met, it appeared immediately that they were not in accord. He thanked Barth for what he had done while he had been in prison and said that he would now resume the leadership and show how a revolution should be made. Barth begged him most earnestly not to act wildly, and spent the next two days in urgent and anxious endeavours to bring him into line and avoid wasting all the good work of the last eight months. Eventually Liebknecht consented to come to a general committee meeting and talk the matter over. This he did, but annoyed and alarmed the committee by bringing with him four friends, unknown to the committee, and in spite of his having been specially asked to come alone. He made an impassioned speech, which was, however, more suited to a mass meeting of his constituents than to a group of hard-headed business-like conspirators, and concluded with reproaches for their idleness during his absence.

Barth replied very tactfully, though he must have been furious. He attributed Liebknecht's misconception of the situation to his long and gallant service in prison and recalled how the first demonstration of May-day, 1916, had only led to his arrest and suppression of the movement for 11 months; how the second, in April, 1917, had been followed by eight months' subjection, and so on; demonstration followed by repression and repression followed by inaction. He pointed out how the morale of the masses followed the military situation and concluded by demanding discipline and no independent action.

After an inconclusive discussion the meeting was adjourned till

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the 28th. Barth was much troubled by Liebknecht's indiscretions, and on one occasion threatened to shoot him if he gave any more trouble. The discovery by the police of a store of hand grenades' and the arrest of an important "storm-troop" leader showed that things were approaching a crisis.

It was on the 28th October that the mutiny among the sailors broke out in the 3rd Squadron, and by the 31st the whole fleet was in revolt. Information about this seems only to have reached the capital piecemeal, and though no doubt it would, in itself, have sufficed to bring about the revolution, almost as soon as it actually occurred, the U.S.P. seems to have carried its preparations forward with little reference to events in the Navy.

Probably much bloodshed was for the moment thereby avoided.

A certain Lieut. Beerfelde was for some time the technical military adviser to the U.S.P., but he had for some time been in prison, and it is not till now that it was thought necessary to find a successor for him. Eventually Ledebour produced a certain Lieut. Waltz (*alias* Lindner). He was not altogether trusted, though if he was to be of any use he had to be told enough to make him dangerous. Care was, however, taken to keep from him the exact location of the house chosen as headquarters for the day of revolution, which was now carefully prepared and stocked with 100 rations. On the 1st November Barth proposed that the 4th should be *der Tag*. All provincial reports were good, and everything seemed ready, particularly in the Army and the troops round Berlin. On the 2nd the matter was further discussed, plans were gone over carefully, maps marked and dispatch riders and guides all told off. Then the committee's courage began to fail; the more they looked at it the less they liked it, and eventually, much to his disgust, Barth had to agree to a postponement till the 11th. He personally was having a particularly trying time, since he dared not go into his own house, though he knew that his two children were very ill. He describes how the first intimation he had of the death of one of them was, when passing down the street seeing a coffin being carried into the house. The postponement was not a simple thing to arrange, particularly in so far as the troops were concerned, but by strenuous efforts it was managed. Apparently the co-operation in Austria, which had been arranged, could not be altered. However that may be, the Austrians did not wait, but went ahead independently. In the result this had no ill effects, but if they had been suppressed the task of Barth would have been made much more difficult.

On Wednesday, the 6th November, when a conference of the principal "storm-troop" leaders was being held, warning was given that the house was being watched. Barth let everyone out by a back way, then, in a spirit it seems of pure bravado, went himself to the front door, where he was met by a Lieutenant with three

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lorry-loads of troops. He appears to have so annoyed the young officer that he was kicked down the steps and told to clear off—which he did.

On Friday, the 8th, another meeting was called, but before it met, Barth rang up several of the more important men, only to find that they had been arrested. He decided to act at once, and called the "storm-troop" leaders, and such of his colleagues as he could get hold of, to a meeting at eight o'clock that evening. After posting outposts all round the quarter, to ensure that the police could not approach without warning, he took the chair and spoke as follows:—

"Comrades, the meeting is opened. Däumig, Müller and Liebknecht have been arrested. I ask for power to act at once. Those in favour hold up their hands. Those against? Thank you; the motion is carried unanimously.

"Now—I dictate. To-morrow is the day.

"I dictate a second time. No one of you is to go home to-night.

"I dictate a third time. From 6 a.m. to-morrow you are not to go about alone, but always in pairs, so that one can watch the other. This is not mistrust, it is merely prudence. Now the meeting is adjourned, while I write orders for to-morrow."

He then drew up the proclamation calling a general strike for the next day and ordered 30,000 copies to be ready by 4.30 a.m. Next he put the finishing touches to his already prepared orders, but had no sooner done so than a dispatch rider arrived with a complete set of the Government orders for counter-measures.

These showed that the plans had been given away, and a completely fresh set had to be made out; by dint of feverish work they were ready by midnight, and were then gone through with the "storm-troop" leaders. The necessity for most vigorous action was impressed upon them. Violence was to be avoided as far as possible, but if anyone refused to come out of the workshops he was to be persuaded with a pistol to his nose! Anyone offering resistance or even arguing was to be shot at once; but no violence!

Columns were to be formed with the employees from each factory or group of factories, with one-third of the "Storm-troops" in front, one-third behind, and one-third distributed along each side, to keep the formations intact, and prevent looting. The danger of allowing looting to break out was very thoroughly understood by all the leaders, and very little of it occurred during the early days of the revolution.

The route to be followed by each column was carefully marked on maps and explained to the men told off as column guides. Any police who attempted to oppose the column were to be attacked at once by the "storm-troops," but if they then cleared off they were not to be pursued. Soldiers, if armed, were to be invited to join the

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"storm-troops" leading the column; if unarmed they were to fall in in rear.

Factory gates found closed were to be broken open, and delegates sent into every barracks to fraternize with the troops; particular care was to be taken to do nothing likely to provoke them. If the troops declared for revolution their officers were to be placed in arrest in barracks, for their own protection. Every dispatch rider and guide was to arrange for an efficient understudy to take his place if necessary, and dispatch riders were to bring reports hourly from each column, of which there were eleven, to headquarters. These reports were to be short and in writing and were to state:—

The names of factories visited and the numbers of workmen in them;
The numbers which came out on strike;
The numbers which joined the column;
Details of any collisions with troops or police with approximate casualties;
Numbers of troops joining the columns;
The position of the column at the time of reporting, and the position it was expecting to reach in an hour's time.

The first reports were to be sent in at nine o'clock. Rendezvous for troop leaders for issue of hand-grenades were arranged, each leader being ordered to bring a carrying party with sacks or baskets.

The meeting then broke up.

On his way to his headquarters the police made an attempt to arrest Barth, but his escort drove them off, and by six o'clock he was sitting alone in the obscure house which had been chosen, waiting for the storm to burst. Till ten o'clock he heard nothing, then reports began to come in, showing all going as well as, or even better than, he had hoped. At 11.15 he issued orders for the advance to the final objectives, the War Office, Town Hall, Wilhelm Strasse and Reichstag buildings, which were duly taken almost without resistance. The Kaiser announced his abdication and the revolution had begun. Barth's work was done. He joined with Scheidemann in the provisional government which was immediately formed, but things did not go the way he wished. He proved himself more and more out of sympathy with his colleagues and after a few months retired into private life. Some of his one-time colleagues were less fortunate, Kurt Eisner, Rosa Luxembourg and Karl Liebknecht all meeting their end in the turmoil and bloodshed which reigned in Germany in the early part of 1919.

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ENGINEER FIELD PARKS IN MESOPOTAMIA.

By MAJOR F. C. MOLESWORTH, R.E.

SOME interesting articles on the subject of the supply of engineer stores to armies in the field have appeared in the *R.E. Journal* lately. The following notes on Engineer Parks with the Mesopotamian Expeditionary Force may prove useful.

The campaign in Mesopotamia can be divided into three portions: first, a period of uninterrupted success, beginning with the landing at Fao on November 6th, 1914, and ending with the battle of Ctesiphon on November 22nd, 1915; secondly, a period of reverses, beginning with the retreat from Ctesiphon, and ending with the fall of Kut on April 29th, 1916; and lastly, a resumption of successes, which lasted till the Armistice. Of these, the present article deals with the first two only, as the writer was invalided in June, 1916.

In common with all administrative services in all theatres of war at that period, it was, for engineer parks, a time of trial and error. It is these trials and errors, however, which contain the most valuable lessons for the future, and on these early mistakes was built up the organization which succeeded.

The force to be served grew from two brigades at the date of the occupation of Basra to two divisions in April, 1915, after which its strength remained stationary until after the battle of Ctesiphon, when one all-British and two mixed Divisions were added.

The arrangement by which engineer stores were supplied to forces based on India was by means of engineer field parks, six of which existed in peace time, that is to say, the stores were kept in Ordnance charge in certain arsenals, and stationery and books in M.W.S. Offices. The personnel was found from various sources on mobilization.

The list of stores was based on the Tirah campaign of 1897–98, and had undergone little alteration as the result of subsequent expeditions. The list was contained in *Army Tables, Engineer Units*, from which it appeared that a Field Park was intended to serve a division of all arms. The list was fairly comprehensive, but the quantities therein, when the stores did arrive at Basra, represented in most cases only a few days' consumption. It is only fair to state that the preamble in *A.T.* stated that the list was only intended to

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facilitate the selection of equipment for any particular operation. The personnel was laid down as :—

1 B.O.
2 B.N.C.O.'s.
2 Indian N.C.O.'s.
12 Indian artificers (followers).
12 Indian Khalasis (*i.e.*, superior coolies, also followers).
1 Indian clerk.

However, mobilization of the Field Park (No. 5) did not take place until late in November, 1914, and consequently a good deal of improvisation had to take place ; the British personnel did not reach Basra until early in December, the stores did not fetch up until early in January (they were delayed in the Shatt-al-Arab owing to quarantine) and the Indian personnel arrived as late as January 26th. But early in November, as soon as the destination of the 6th (Poona) Division, then mobilizing, was known, the purchase of a large quantity of engineering stores was ordered. These were obtained in Bombay, and loaded on the *Ganges*, which sailed soon after the headquarters of the division.

Basra was hopelessly lacking in open spaces big enough to dump any quantity of stores. The Shatt-al-Arab river was bordered by continuous date-palm groves extending two or three miles back. As an Arab saying puts it, " The date-palm does best with its feet in water and its head in hell," and consequently all the date-groves were, naturally or artificially, below H.W.M. Perpendicular to the river were canals, primarily for the irrigation of these date-groves, secondarily for navigation by flat-bottomed boats called *ballams*. The canals were bordered by *bunds*, often wide enough only for foot-passengers, and, as experience subsequently proved, very liable to be breached at spring tides. A rather wider *bund* banked the river. There were no metalled roads, and communication parallel to the river was only possible by narrow paths winding through date-groves, crossing the canals by precarious bridges. It was, in fact, easier and quicker to go any distance by *ballam* instead.

Reports late in the campaign on the port of Basra commented adversely on the congestion of small buildings along the river-front, but the authors did not realize the cause thereof, namely, that at the beginning of operations the river *bund* and its immediate neighbourhood constituted the only practicable space for building ; inland was an uninterrupted series of date-groves whose very existence depended on their periodic inundation.

It was not only a case of establishing a base, it was one of creating dry land to put a base on. Almost the only localities above H.W.M. were occupied by Arab villages.

The *Ganges* arrived in the stream on November 27th, five days

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after the occupation of Basra, and began discharging stores. These were placed in charge of the writer, assisted by a R.E. N.C.O. and an Indian sapper. It was at first proposed to use the tennis court of the German Consulate as a park—the park eventually occupied 70 acres, but, before any stores were dumped there, R.E. H.Q. was moved to what was afterwards known as "Engineer House," and the park was placed on the site of a demolished Arab reed-mat village.

The discharge of the *Ganges* was by no means easy.

There were no berths or piers for ocean-going steamers; in fact, there was only one pier, and that a very small one, in the whole of Basra.

The lighters, a species of boat of about 30–40 tons, called *Muhailahs*, were in charge of Arab captains, to whom instructions could only be given through the medium of very second-rate interpreters; the *Muhailahs* used, therefore, to make for the shore and drift downstream until commandeered. As building operations were in progress in many parts of Basra, many *Muhailahs* were unloaded by working parties and lost sight of. But the bulk fetched up at Engineer House, and the Field Park began to function.

In early days there was naturally a struggle between various services for space. The Field Park had to fight with the Ordnance, Wireless Telegraphs, and Indian Base Depôt for space, and the result was a jig-saw puzzle. High ground, as stated above, was very limited. Indeed, as it proved afterwards, all our ground in that neighbourhood was liable to flood.

The Wireless shortly discovered that they wanted to spread earths over the greatest part of the park, the result of which was that trenches had to be cut and stacks resorted. As more stores arrived, the park had to expand, which could only be done inland into date swamps. Of course, the filling in of these swamps was taken in hand early, but earth had to be brought by boat and the process was very slow, besides which the Field Park had to compete with other sites as regards supply of earth, and was naturally a poor second to locations for troops. The spring of 1915 produced some extremely high tides. There were no records to go by, but the fact that these floods destroyed fruit-trees on the river bank, which must have been 10 or 15 years old, showed that they were exceptional. *Bunds* were heightened, but serious floods occurred through the breaking of some of them, besides which water seeped up through the ground. Eventually the E. and M. Company undertook the pumping-out of the area, but the trouble recurred in the spring of 1916. Although by that time the earthed area had been largely increased, the total area of the park had increased very much more, and the result was that the greater part of our timber yard was 2 ft. deep in water.

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Here it may be remarked that rain turned the soil into mud of a glue-like consistency. After showers, which were frequent during the cold weather, the park therefore became a marsh.

A greater danger was fire. Fortunately there was only one. This originated in the Telegraph area, and in the hopelessly congested state of the river front area spread rapidly and was within a few yards of the park magazine, the eaves board of which had actually started smouldering, when its progress was stayed. A very small amount of Field Park stores was destroyed.

Mention has been made of the one and only pier in Basra. This, though of the flimsiest construction imaginable, served to land an incredible amount of stores, until it finally gave way, but meanwhile a longer and better pier, running out far enough to take *Muhailahs* at almost any tide, had been built. From this a 2-ft. gauge tramline, made chiefly from scraps discovered in neighbouring yards, was run into the park behind, helping materially in shifting stores. More piers, and further extensions of the tramline, followed as the park expanded.

The first office of the Officer Commanding Park consisted of empty barrels with corrugated iron sheets laid across, the second of a portable magazine, 6 ft. cube internally, in which explosives had come from India, the third, a brick building with a mud-on-corrugated-iron roof, was constructed by park labour, and served to house H. Q. until July, 1916; workshops, stores, godowns, section offices, magazines, and other buildings were made, or adapted from existing buildings, the size increasing as the Force expanded, and the style improving as it was realized that we were in for a long campaign.

There was no official manual in existence which gave any indication of the purpose for which engineer field parks existed. However, we presumed that their purposes were to replenish equipment of engineer units and to supply engineer stores to all formations, and acted accordingly.

What exactly were and were not engineer stores was a question which constantly cropped up between us and the Indian Ordnance Department and the Supply and Transport, and, in fact, continued to the end of the campaign. Peace-time regulations were, of course, a guide, but a most confusing one. For instance, in peace time the S. and T. supplied oil cooking-stoves and the M.W.S. those for all other kinds of fuel. The M.W.S. supplied hip-baths and the Ordnance and S. and T. all other kinds. Was this rather anomalous procedure to continue on field service? Again, there was no distinction in *A.T. Engineer Units* between our own equipment and stores for issue; four tent lanterns were included in the list, presumably for the use of the park staff, but there was nothing to differentiate their purpose from that of, say, the 750 lbs. of gun-cotton we carried; consequently we received indents for both. Units, too, were not unnaturally

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hopelessly ignorant of our functions, and it is difficult to think of an item which we were not asked, at one time or another, to supply. The terms "Field Park" conjured up visions of leafy shades and grassy slopes, and so demands for hay, straw and grass were not uncommon; a demand was received for artificial flowers to decorate the G.O.C.'s Christmas dinner table; but perhaps the strangest of all was that made by a Political Officer for 10 lbs. of chrysolyte; no one knew what chrysolyte was, and its only known use was for one of the foundations of the New Jerusalem (*Rev.* xxi, 20), and consequently the indentor was asked for what purpose it was required. He would not, however, divulge it. Chrysolyte was eventually procured from India, and found to be raw asbestos.

Demands from Units did not err on the side of modesty. In some cases it was possible to provide a scale, *e.g.*, two 400-gallon tanks per battalion. Later on, when a Works organization was started on L. of C., indents from Units for building materials were *vetted* by the local Works officer before stores were issued.

The employment of local Arab labour was begun within a few days of the inauguration of the Park, at first through a contractor, but in a very short time, directly.

Skilled labour—carpenters, blacksmiths, masons, etc.—was on the whole satisfactory; an interpreter was needed at first, but in a surprisingly short time the British ranks learned enough Arabic to carry on. It may be remarked that, until March, 1915, most of the building work in Basra was supervised by the field park staff. Labour was paid—always by an officer—on 10-day muster rolls.

An increasing amount of local labour, men, women and boys, was needed for loading and unloading. By the beginning of 1916 practically all the casual labour in Basra was employed by the various departments along the river front, with the result that the labourer selected that where work was easiest and hours shortest: the park fared badly. As a result, the whole control of such labour was taken over by a local British firm, and though the result was not entirely successful, at least it ensured that we got our share.

Naturally, as the force expanded, further personnel had to be obtained from India. The strength of British W. and N.C.O.'s was doubled by May, 1915, and by June, 1916, was several times its original size; Indian N.C.O.'s were got out similarly. Two more officers were added in March, 1916. Indian Storekeepers and an Indian Accounts establishment were also added. Several stray Indians applied for work and were taken on, and some Armenians —deserters from the Turks—were added.

Unfortunately, sickness in the summer months reduced our numbers; it was no uncommon thing for a Britisher to be taken direct from work to hospital and thence to India. One very hot day in 1915, more than half the supervising staff reported sick, mostly

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with heat-stroke. The dislocation to accounts resulting may be imagined. The devotion of many of them to their work, when they ought to have reported sick, was beyond all praise. By June, 1916, one I.N.C.O. only remained of the staff who had originally come out with the park, and the second lot, who came in May, 1915, were beginning to disappear.

As the park expanded, organization into sections became necessary; those eventually adopted were :—

A. Stores received from Ordnance.
B. Workshops and furniture.
C. Timber, bridging material and bulky stores.
D. Hardware and small stores.
E. Dispatch of stores.
F. Office and accounts.
G. Receipts of stores from India.

As soon as the numbers available allowed, sections A–D were placed under an officer named O.C. E.F.P., and sections E and G under another called the "Embarkation Officer."

For supply of stores we were dependent on :—

(*a*) Captures from the Turks.
(*b*) Local purchase.
(*c*) Indents on India.
(*d*) The Ordnance.
(*e*) The E.F.P. Workshops.

As regards (*a*), several Turkish depôts were found in Basra, but the Arabs and then the field companies S. and M. got there first, and left, generally speaking, only a gleaning of heavy or unserviceable articles. The best find was the naval workshop on Ashar creek, but, in December, 1915, we had to hand it over to the Royal Indian Marine, who, much to our disgust, began sending us contingent bills for stores we got from them which had been there at the time of our handing over. The question was referred to the Accounts, who upheld the action taken by the R.I.M:, and thereafter two branches of H.M.'s Forces engaged in smashing the Turk had to bill each other for stores, to the great complication of accounts. Presumably, however, we satisfied some white *babu* in India.

Another find was in the godown attached to the German Consulate in Basra, where some 20,000 cub. ft. of timber was discovered; this was eventually paid for to an organization called the "Hostile Trading Co."

(*b*) Local purchases were made very largely in early days. There was a number of British and other firms with large stocks. These were taken over as required, and the firms replenished them from India. This procedure was encouraged, as it ensured that there was a large reserve handy; it saved us from further encumbering our

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scanty stacking ground; and as such stores were delivered direct where required, it saved us the trouble of unloading. The price was at first arranged by bargaining, but later, contracts were made for a period of three months at a time for :—

(i) Furniture.
(ii) Reeds and reed-mats.
(iii) Hardware.
(iv) Bamboos, *chandals* (*i.e.*, poles) and pickets.

The first lot of tenders opened nearly all read " 5 per cent. lower than anyone else," but the contractors soon learned to quote figures.

With the exception of (iv) above, no contract for timber was made. This was because no one contractor could possibly have imported and stored the enormous quantities required. Any stock of timber imported was bound, sooner or later, to be taken over, at prices regulated from time to time by the B.G. R.E. or D.W.

As regards (*c*), orders for stores from India were sent by monthly indents, supplemented by special telegraphic ones. At this time, the only organization was the establishment of A.C.R.E. Bombay (the late Lieut.-Colonel Watson, V.C., R.E.) who, without any addition to his normal staff, undertook the purchase and dispatch of stores valuing several lakhs of rupees monthly. The average time taken from dispatch of indent to receipt of goods was at first about six weeks. This compared most favourably with the time taken by the Ordnance to comply with our indents, which was often nearer six months. It was, however, impossible in the early months of the campaign to get invoices, and usually the only intimation we got was the ship's bill of lading, which was by no means perspicuous—for instance, " iron plates " might mean loop-holed plates, plain or corrugated iron sheets, or even electrical stores.

(*d*) The stores obtained from Ordnance were mostly standardized patterns of tools, *i.e.*, " Vocabulary stores." We indented monthly, and what Ordnance could not supply on the spot, they ordered from India.

(*e*) Manufactures in workshops included a vast variety of articles of furniture, hand-grenades, portable ramps for steamers, grave-boards, plane-table stations for use in marshes 4 ft. deep, ice-chests, punkahs, Sibley stoves, etc.

At Basra, units had to send parties and transport to draw their own stores, though exceptions were made in the case of hospitals. But after the occupation of Kurnah on December 9th, 1914, the dispatch of stores up river had to be thought of. Consignments were sent on river steamers, or more often on a barge tied to a steamer, with an I.N.C.O. in charge. Later on, as the Force spread up the Tigris, Euphrates and Karun, and to Bushire, 200 miles away across the Gulf, it was impossible to send anyone up, and stores were

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consigned under a way-bill. After the occupation of Amara in June, 1915, it was usually impossible to obtain passage by steamer and a contract was made with Messrs. Lynch Bros. on a tonnage basis for transport in *muhailahs*. During the attempted relief of Kut, practically all the *muhailahs* available were kept with the relieving force for use in the event of an advance. Most of them were empty, but to return them to the base would have given Turkish airmen a hint that a forward move was not intended, and it became practically impossible to send up any engineer stores unless a G.O.C. up river specially asked for space to be allotted on a steamer. After the fall of Kut, matters righted themselves, and we sent up 800 tons during May, 1916.

With this extension of our activities, the question of the affiliation of field parks at out-stations came up. The first to be formed was in 1916 at Ali-al-Gharbi, where a convoy of *muhailahs*, which just failed to get into Kut, had discharged cargoes. This park fed the Tigris corps, but for the reasons stated above, could not be replenished and practically dwindled to nothing. The parks at Kurnah and Amara, which supplied stores chiefly for local use, were soon afterwards added, and in May, 1916, a park was established at Magil. A timber depôt was also formed at Sarraji, two miles downstream from Basra. These parks were under an officer or barrack warden or N.C.O.

The system of accounts produced long correspondence with the Controller of Military Accounts. Here again no definite instructions existed. The accounting for stores was a task of great difficulty, complicated by the fact of our start without staff, by the delay in getting invoices from India, by constant sickness and casualties, and by the fact that accounting had to take second place to getting stores off. In fact, in "C" section we never got square with timber.

Contractors from whom local purchases were made produced bills, which were sent to the Controller of Military Accounts for payment; but increase of work, combined with shortage of staff in his office, gradually lengthened the time it took for a bill to get through from one to six weeks, by which time contractors were becoming restive. The Controller of Military Accounts eventually agreed to pre-audit payments, after which things went smoothly. A form, borrowed from the Supply and Transport, was introduced with a purchase order on one side and bill on the other—an immense saving of labour. The amount spent locally, chiefly on purchase of timber, amounted by May, 1916, to several lakhs of rupees.

An imprest account for small payments was also kept.

Mention has already been made of the extraordinary system by which we and the R.I.M. billed each other for stores transferred. The Accounts people insisted on our extending the system to the Navy, the Basra Municipality, the Customs, Port Administration and

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several other organizations to the enormous complication of accounts. The Basra *vilayat* administration we had to bill with 24½ per cent. supervision charges. We sent, by order of the Controller of Military Accounts, the D.D. Works a debit for all the stores we issued to Works organizations, but what happened to these debits, or for what purpose they were called for, we hadn't the least idea.

A few notes on particular stores may be of interest :—

Barbed Wire.—Demands for barbed wire far exceeded supplies, and we had to send constantly increasing indents to India. *A.T. Engineer Units* provided 28 cwt. 1 qr. 18 lbs. of barbed wire, with a rather smaller quantity of plain wire. A footnote stated that these were intended for entanglements, frontage of one Army Corps —an allowance of a little over a foot per rifle. It is only fair to say that No. 5 Field Park brought out a larger amount. At the time of the attempted relief of Kut, we had a standing order on India for 30 tons monthly. Each consignment should be accompanied by about one-tenth of its weight of plain wire; about 12 S.W.G., for stays, and, if screw pickets are not available, by about one-hundredth of its weight of 20 S.W.G., for binding.

Bombs.—The Field Park manufactured hand-grenades of the McClintock pattern. In spite of several improvements it was found that they seldom detonated properly on muddy ground, and that they were difficult to light in damp weather. Manufacture was given up when Mills and other patterns came into use.

Bricks.—The usual pattern available was about 9 in. × 9 in. × 2½ in. ; reeds were used for fuel, and consequently the bricks were usually underburnt. The local method of building a wall was to build two skins of bricks in *juss* (to be described later), filling the space between with bats. We had a contract for supply of bricks, which the Works organization took over on arrival.

Juss.—The local substitute for mortar was an impure form of plaster of Paris called *juss* ; it made excellent plaster.

Matting.—Enormous quantities of matting were required for hutting. In Mesopotamia mats were made from reeds.

Sandbags.—Mention should be made of a consignment of about 50,000 sandbags, sent out by some well-intentioned but misguided Red Cross Society, which had mouths just big enough to insert a hand.

Water Tanks.—A 400-gallon tank, measuring 4 ft. × 4 ft. × 4 ft., is a trade article in India. This is an inconvenient size for carriage on Army Transport carts, and a 200-gallon tank, 4 ft. × 4 ft. × 2 ft., was found better for the purpose. Brass taps are very liable to be stolen by Indians ; they should be sent separately (complete with back-nuts) in burglar-proof cases.

Timber.—In the early stages of the war, little use was made of Indian timber. The timber commonly used in Bombay is teak;

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softer and less expensive woods are eaten by white ants there. Teak is quite unsuited for field work. The timbers of N. India, *deodar, chir*, etc., were almost always cut to sleeper sizes, too short for field use. Local merchants imported *punak, saraia*, and other species from Singapore, and it was those kinds that we used most of. *Chandals* (long poles) were imported from Zanzibar. Occasionally a firm imported a shipload of deal from Scandinavia, which we took over bodily.

The following are notes made for future guidance :—

Engineer reconnaissance should include items of interest to park officers, such as local stocks of engineering materials, firms who are likely to stock such, notes on local skilled and unskilled labour, stating current wages, and what seasons of year labour may be hard to get (*e.g.*, in Iraq labour was scarce during Ramzan, the Mussulman month of fasting), particulars of local timber and other building materials.

Glossaries in military reports should include technical engineering terms.

H. Q. of the engineer park should be at the base, dispatch of stores to which should be undertaken by an officer in the country whence stores are sent, *e.g.*, at Bombay in the case of Indian overseas expeditions. He should have ample powers of local purchase, and must be *ex-officio* on the Embarkation staff and acquainted with shipping or railway regulations as the case may be. Each consignment should be accompanied by a priced invoice, and each package should be marked with indent number and item number of indent.

The most suitable organization is a base park at the base, with advanced parks close behind fighting formations, and smaller parks at posts on L. of C. The O.C. Field Parks should be under the D.W. on L. of C.

The strength of the base park, of course, varies with the amount of stores to be kept, but the following functions have to be considered :—

(*a*) Receipt.
(*b*) Custody of stores.
(*c*) Dispatch.
(*d*) Manufacture.
(*e*) Local Purchase.
(*f*) Accounts.
(*g*) Personnel.

(*c*) should be in charge of your best officer ; as pointed out by the author of the " Supply of Bulk Stores in War," engineer stores come off worst when there is a transport shortage, and you want a wide-awake and pushful officer to seize every opportunity of forwarding the goods. If officers are short (*a*) and (*c*) may have to be under one,

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and (*b*), (*d*) and (*e*) under another. Local purchase may be arranged for by a separate organization, in which case you will want an inspection section. If it remains a park function, it is imperative to see that you are not competing with other departments.

Duties of the officer i/c parks should include frequent visits to the front to consult officers using his stores.

(*a*) Receipt of stores should arrange for superintendence of unloading (a railway or port function, but a park representative must be there to see that cement barrels are not dropped 20 ft. into a lighter) and delivery in park.

(*b*) Custody of stores should include inspection and testing (in the case of explosives, arrangements must be made for testing every three months), not neglecting care of machinery, and collection and stacking of materials for dispatch, at places selected by the section (*c*). This section will generally have to be divided into convenient sub-sections.

(*c*) Dispatch to take over stores stacked by (*b*) and load; each consignment to be way-billed, and, whenever possible, accompanied by a representative. This section to be responsible for delivery to consignee.

(*d*) Manufacture includes repair of salvaged articles. Articles manufactured or repaired to be handed over to (*b*)—except in compliance with urgent indents, when they would be handed over to (*c*), and information sent to (*b*).

(*e*) Local Purchase arranges contracts for stores, which should include delivery in the sub-section of (*b*) concerned, and inspects same. Local Purchase officer to keep himself informed of stocks in possession of local firms, and must see that he is not raising prices by competing with any other part of the Force.

(*f*) Accounts. Sections (*a*) and (*e*) keep accounts of receipts and issues. (*f*) section checks and coordinates these, submits bills for local purchase to C.M.A., and controls imprest. *N.B.*—Section officers pay their own local labour. In dealing with oriental labour it is important that men are paid by the officer who employs them.

(*g*) This section performs adjutant and quartermaster duties for enlisted or enrolled personnel, and coordinates demands for outside military or local labour.

Advanced parks should be organized similarly; but, of course, on a smaller scale.

In moving warfare, it is a good plan to have an ever-ready park available for dispatch to or with any force, *i.e.*, personnel should be detailed, stores earmarked and transport calculated.

Orders for the organization of the force will detail establishment of the park; the stores to be obtained will probably be left to the discretion of the C.R.E. It is most unlikely that the stores will be ready at the same time as the fighting troops, but, in any case, a

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skeleton formation should accompany the Force to the spot where it is intended to form the Base park, to stake out a claim for ground,* reconnoitre for engineer stores, arrange for local purchase, etc. It will be as well if a part of the personnel, with a few stores, accompany this advanced party to open up the workshops.

Among the first demands to be made on the park will be : notice boards, incinerator bars, coffins, water-tanks and troughs.

Standing Orders for the parks should contain :—

(*a*) Sanctioned war establishment.
(*b*) Organization and duties as detailed above.
(*c*) Financial powers of officers regarding purchases, contracts and writing off losses.
(*d*) Instructions *re* care of machinery, testing of explosives.
(*e*) List of reports and returns.

It is a useful ideal—one we never managed to attain in Iraq—to have a catalogue for the use of all indentors, giving illustrations, weights and uses of every article supplied. But to get this out, and keep it up to date, would take a whole-time officer and a large clerical and drawing staff.

* The author of the *Supply of Bulk Stores in War* gives 1000 tons to an acre as a working figure.

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CROSS-COUNTRY TRACTORS.

By Capt. and Bt. Major G. le Q. Martel, d.s.o., R.E.

The suggestion that cross-country tractors should be extensively used for military purposes was first made by a R.E. officer, Capt. and Bt. Major S. H. Foot, m.c., R.E., in February, 1918. This officer pointed out that both man-power and shipping had become of vital importance in the prosecution of the war, and that both these factors were seriously affected by the retention of the great quantity of horse transport in France. At that time there were half a million horses in France, and some 80,000 tons of fodder per month had to be shipped from overseas to maintain these animals. This transport could not be replaced by motor lorries because vehicles at the front were required to go over country tracks and bad roads which were passable to the horse, but not to the ordinary motor vehicle. The suggestion was that the whole of this form of transport should be carried out by light tractors.* Major Foot produced the following points in support of his suggestion :—

(*a*) If tractors were substituted for horses, the tonnage required for the petrol supply would be half the tonnage for the supply of fodder in the case of the horse transport. But this is on the supposition that the tractors would be in full use every day. The horses had to be fed every day, although a large amount of the horse transport was idle for certain periods; with tractors there would be no consumption during idle periods. The saving to the tonnage in shipping would, therefore, be considerably more than 50 per cent.

(*b*) As regards man-power, the saving would be in the neighbourhood of 50 per cent. also. The actual saving in drivers between horse transport and tractor transport would, of course, be much greater than 50 per cent. in the case of the artillery, but this figure allows for repair, manufacture and replacement of tractors.

(*c*) The tractors could negotiate many places which are impassable to horses, and as they would normally move clear of the roads, they would suffer less from shell fire and night bombing. The latter is a most serious consideration with horse transport. The replacement of casualties among horses occupies a considerable amount of tonnage and shipping.

* The word "tractor" is used throughout this article to denote a vehicle which travels under its own power on tracks, and either carries or tows a gun or any other load.

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This suggestion was taken up and the question of the supply of suitable tractors was opened. The supply of these tractors was an engineering problem of the first magnitude and no very definite progress was made before the armistice.

After the armistice the question of replacement of horse transport by tractors was discussed very fully in many military journals. It has been pointed out that the difficulty of transport in the forward area had a large share in the failure of most of the offensives in the latter part of the great war. During the long period of trench warfare the great armies just existed on a perfected system of road and rail transport; but after the initial stages of an offensive, the railways were non-existent in the forward area, and the roads very much damaged; it is, therefore, hardly surprising that every offensive was seriously affected by difficulties in transport. In open warfare the vulnerability of transport which is tied to roads is also very serious, particularly if the enemy possesses an active air force. Then again, in warfare against an uncivilized enemy the one great problem has always been the difficulty of transport. A suitable type of cross-country tractor would solve all these problems, and all thinking soldiers are now convinced of the desirability for this change. Moreover, the tractor which brings with it economy in tonnage and man-power also brings economy in expense, and this is a matter of primary importance under peace conditions.

But now we are faced with the first great problem connected with this question. It is never possible for an army in peace to retain all the transport which it requires in war; the expense would be far too great if this were attempted. Before the war our transport consisted of lorries and horse-drawn vehicles and we could mobilize from civilian resources without any great difficulty. The horse is now dying out in this country and being replaced by motor vehicles on wheels, and the latter would not be suitable for the transport of the army in the forward area. But if we adopt a form of light tractor instead of the horse-drawn vehicle, how shall we mobilize for war? The provision of tractors on a war scale for the whole army and the upkeep of these tractors would entail a prohibitive expense. If we retain the horse transport, we shall be faced with the great difficulty of the supply of horses for war, and if we adopt tractors, there is at present no known source of civilian supply, because the present commercial or agricultural tractor is quite unsuitable for this form of military transport.

This brings us to the second great problem connected with the whole question. Even the latest commercial tractors show great inefficiency compared with the lorry on the road. They are limited to about five miles an hour maximum speed, and at this speed they consume about three times as much petrol per ton mile as a lorry. This inefficiency is mainly due to the method of steering adopted.

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This method consists of applying all the engine power to one track and using a brake on the other track so as to force the tractor to skid round to the desired angle. The inner track stops momentarily while the skid is taking place; Fig. 1 shows the plan of a tractor and the shaded part shows the portion of the underneath of the track which is resting on the ground. The thin lines show the position taken up by the tractor when it is swung through an angle of thirty degrees. This method of steering is known as skid steering, and it is quite obvious that it absorbs a large amount of power. When driving one of these tractors, a very perceptible check can be felt whenever the tractor is taken round even a slight curve. This accounts for part of the low efficiency of the commercial tractor. But this method of steering brings with it a further defect. The track has to be made very strong and heavy to stand the stresses set up by this skidding, and a strong track means a heavy track,

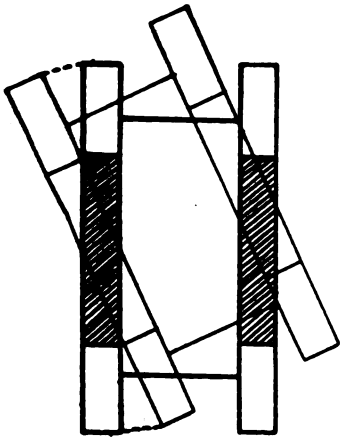

FIG. 1

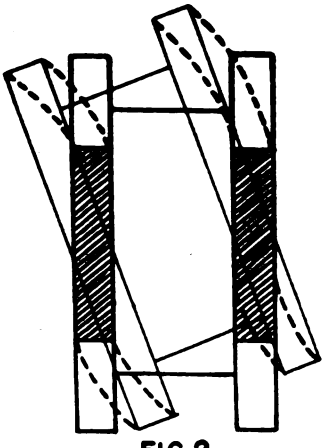

FIG. 2

which, in turn, means extra friction on the rollers, a heavy form of transmission and a powerful engine. This accounts for the remainder of the low efficiency of the commercial tractor. Moreover, a heavy track imposes a limitation on speed, for the transmission losses increase very rapidly at the higher speeds with a heavy track. For agricultural work a low speed is sufficient, and so much power is absorbed by the work of ploughing, etc., that the additional loss due to friction and skid steering is of no great account. But for military purposes we require a reasonably low petrol consumption, and the army would hardly be satisfied with maximum speed of 5m. p.h. It is, therefore, of the first importance to produce some improved method of steering. This comprises the second problem, and although we have made some progress in this direction, which will be described later, we have not yet produced a satisfactory tractor for military purposes.

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These two problems, therefore, place us in a curious position. The horse is dying out and we possess no suitable alternative form of tractor at the moment. Moreover, even if we had reached the design of a thoroughly satisfactory tractor, we could not afford to construct them on a war scale for the army.

Assuming that the satisfactory tractor will be eventually produced (and there is little doubt on that point) the solution of our difficulties lies in stimulating the commercial market. On basic principles, the tractor should have a great future. There are, at present, four known forms of transportation (if we exclude such primitive methods as horses, camels and coolies). We will examine them each in turn.

Railway Transport.—This suffers from three disabilities. It is restricted to one dimensional movement and stores have to be carried or carted to the line of the railway. It entails a large initial expense in the provision of the permanent way. This initial expense is a considerable deterrent in opening up new country. Finally, the railway is limited to a definite maximum load, and hence its efficiency is limited. If it were possible to double the maximum load of trains in England, a great saving in running costs could be effected; but this cannot be done without a prohibitive expense in enlarging tunnels, rebuilding bridges, etc.

Lorry Transport.—This suffers from the same limitations as railways. In addition, the upkeep of roads incurs a very heavy expenditure. If it were possible to use, say, one 9-ton lorry, instead of three 3-ton lorries, the running costs would be considerably reduced. But the roads will not carry a 9-ton lorry.

Sea Transport.—This has the great advantage of two-dimensional movement, and is not restricted to any permanent way. Nor is the size of the ship limited. The ship has, however, to displace a large weight of water as it progresses, and this imposes a distinct limit on the speed of the ship for economic transport purposes.

Air Transport.—This is in the same position as sea transport, but the aeroplane has to fight constantly against gravity, and this consumes a definite portion of the energy.

With tractor transport we find none of these limitations. No permanent way is required, the tractor can move to any desired point, and there is no limit imposed on the size of the tractor. As a result, we find a definite demand for tractor transport from the Colonies, and there will be a ready market as soon as an efficient tractor is produced. Land which is at present valueless, owing to lack of roads and railways, will become valuable, and the cost of transport will fall rapidly in the colonies with the introduction of tracked vehicles. If we can stimulate this market we shall be able to draw on the export trade of this country for war. There is a further possible source of supply. We spend some 50 millions of money a year on the upkeep of our roads in this country and the

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damage to them is almost entirely due to the commercial lorries. If we could produce and universally adopt a tracked vehicle which is as efficient, or nearly as efficient, as the lorry, we would save the greater part of this 50 millions. The saving effected would enable us to subsidize the replacement of the commercial lorry by the tracked vehicle. Cars and light vans on wheels could still be used, because they do practically no damage to the roads. This step is not within the bounds of possibility at the moment, and it is too early to say whether it will eventually be possible, but it is well to remember that the mechanical engineer is seldom defeated by any problem, and the production of a tracked vehicle as efficient as a lorry is only a somewhat intricate mechanical problem.

We can now turn to the problem of producing a tractor with an efficient method of steering, for this is the crux of the whole problem at present. An entirely new method of steering was suggested about 3 years ago by the Superintendent, Tank Design Department. He suggested that the tractor should be suspended on a particular type of rope springing, and that the track should be constructed with lateral flexibility. In this way, he suggested, that the tractor would be able to negotiate easy curves without skidding. Fig. 2 shows a plan of a tractor which is constructed in this way. When the power is applied to one track only, the tractor swings through an angle, but the portion of the track which was resting on the ground remains in that position. Thus the track takes on an " S" form shown by the dotted lines As the tractor proceeds, it lays the track on the new alignment so that no skidding need take place. The tractor can, of course, only swing through small angles in this way, or describe easy curves, without skidding. A further advance consists of pivoting the front horns of the vehicle so that the track can be laid in a sharper curve. Alternatively it may be possible to negotiate sharp bends by the use of two pairs of tracks of which the front pair can be pivoted like the forecarriage of a cart. Each of these pairs of tracks would, of course, need lateral flexibility so that they could be laid in a curve, but by using two short tracks a much sharper curve could be laid. Experimental models which have been constructed on these lines have shown a great increase in efficiency over commercial tractors, and this is mainly due to the skidless steering and the light tracks which can be used.

But these experiments have naturally been accompanied by numerous minor difficulties ; broken tracks and minor troubles have been frequent. Nor will the whole problem be solved in a few months. Any invention, such as a military tractor, passes through three stages :—

(*a*) *The stage of applied research* in which we seek to learn the various methods by which the problem can be solved, *i.e.*, what different types of track can be used, and how do they compare in efficiency ?

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(*b*) *The design stage* in which we design the actual machine (a tractor in this case) to fulfil different requirements and test this design to discover and remedy any weak points.

(*c*) *The production stage* which must never be entered until the design has been most thoroughly tested in every possible way. History is full of examples in which a machine has not emerged from the production stage for two or three years, owing to undue haste in the design stage (the omission of some test which would only have occupied a few weeks).

As regards the tractor we are still in the stage of applied research. Unfortunately the requirements of the moment and research for the future became confused after the war, with the result that little progress was made. The position is now much better. For our immediate requirements we are constructing track vehicles (tanks and tractors) on lines which have been well tested. The result is that we shall have tanks which are sound and reliable, but no great improvement on the war tank. With tractors we shall get reliable machines, but not efficient from the point of view of economic transportation, and they will have no commercial use. The research work for the construction of efficient tractors is being taken up by civilian firms and great progress is being made, especially in the direction of skidless steering. There is every likelihood of a really efficient tractor being produced within the next two years. The French have stimulated great interest with their Kegresse machine. By using front wheels and short tracks on the rear axle they have eased the problem of steering, but they do not employ a track with lateral flexibility, and their present machine is limited to fairly light loads. There is every reason to hope that the British civilian engineers will produce a machine which will far exceed the capabilities of the French within the next year.

In the meantime, we must retain our horse transport until the problem of producing an efficient tractor has been solved. The horse is dying slowly, and we have several years of grace before we reach the stage when we cannot mobilize our horse transport. But when we have solved this problem we shall then have to turn to the first problem which was outlined at the beginning of this paper. This problem is entirely one of mobilization. We shall not be able to keep more than a small proportion of army tractors in time of peace, and our successful mobilization will depend on the extent to which the commercial world has adopted tractor transport. We shall have to change our transport gradually. The artillery is an arm which lends itself pre-eminently to tractor transport. The saving in men and fuel or fodder is very great, and this saving should enable us to build a fairly large number of tractors. By equipping artillery brigades with tractors we can reduce very largely the

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number of horses required for mobilization, and we could keep the peace scale of tractors very near the requirements for war. As horses become scarcer we shall be forced to transfer more horse transport to tractor transport, but by that time the tractor may be a commercial article, which will solve the problem of mobilization. We have also eased the problem of mobilizing the horses by transferring the B echelon of the D.A.C. of a division to motor vehicles; though unfortunately the most suitable vehicle for this purpose—the 30-cwt. lorry—is only used in small numbers in this country, and is not very easy to obtain for mobilization. The conversion of a brigade of artillery from horse transport to tractor transport is being tried experimentally, but no great progress has yet been made.

The conclusion may be summed up as follows:—

(*a*) The tractors and tanks which we build for our immediate requirements must be constructed on the lines of the agricultural tractor and the war tank. They will, of course, be an improved model, and will have a somewhat higher speed, but they will not provide an economic form of transportation. A reliable machine cannot be produced at the moment, which will have the very high speed which has been attained by a few experimental machines.

(*b*) The research work, which was not done at all thoroughly by the government department during the last four years, is being taken up by civilian firms, and there is every prospect of a great advance being made in an economic form of cross-country traction. Many different types of track and transmission will be tested, and we shall be able to collect the necessary data to enter the design stage in the construction of really efficient tractors and fast tanks. We must endeavour to persuade commercial firms to take up this work, and to standardize parts as far as possible so that the commercial tractor may be suitable if required for war.

(*c*) We shall have to start by using tractors for such work as that of replacing the horse teams in the horse and field artillery, for a greater saving is produced by this replacement than by replacing the horses in, say, infantry transport. This saving may enable us to maintain a high percentage of the requisite artillery tractors in time of peace. The difficulty of the supply of horses on mobilization will be considerably eased by the mechanicalization of all artillery units.

(*d*) This difficulty of the supply of horses may be further eased by converting a proportion of second-line transport from horse transport to light lorries, if the supply of light lorries remains available.

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(*e*) We shall be able to construct a certain number of tractors for supply work in warfare against uncivilized countries. In places such as India or Mesopotamia, the saving effected by the use of tractor transport will easily pay for the capital cost of these vehicles.

(*f*) The complete conversion of all horse transport to tractor transport, which brings with it enormous military advantages, can only be undertaken if the engineering industry of this country takes up the construction of tracked vehicles for use in the colonies or at home, and thus provides a source of supply for mobilization in the event of war.

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PROFESSIONAL NOTES.

ENGINEERING.

Well Boring Operations at Tidworth during the Summer, 1922.

Owing to the drought of 1921, it was decided to sink a bore at Tidworth, to ensure an adequate supply of water.

The chief factors which governed the estimated size of the bore were :—

(*a*) The average consumption of water, which was put at about 300,000 gallons a day, and

(*b*) The water table level at which the existing well would fail to meet these requirements, namely about 250 ft. above Ordnance Datum.

It was thought that the bore would probably have to be sunk some 500 ft. before the necessary yield could be obtained ; and the water would have to be raised by means of an air compressor plant. It was estimated that the bore should be ten to twelve inches in diameter at the top to allow for the possible necessity of reduction in diameter during sinking.

A Conference was held at the War Office on the 12th April, at which it was decided to carry out the work by a detachment of one serjeant and five sappers who were under instruction in well boring at the S.M.E., Chatham, and that the plant to be used would be supplied from stock. This decision ultimately governed the size of the bore, which was fixed at 8 ins.

There were two alternative sites for the bore, in the valley of the River Bourne, or in the downs near the existing well. The former site had the advantage of being some 70 ft. nearer the water level, but had the disadvantage of requiring additional outlay in mains and pumping plant. The latter site was chosen, the height at the surface being 450 ft. above O.D.

As the sapper crew from Chatham were not fully qualified as well borers, the services of Mr. G. T. Palmer, ex-serjeant, Royal Engineers, and an employee of the Mersey Docks and Harbour Board, and formerly in charge of No. 3 Water Boring Section, R.E., in France, were obtained to supervise the work. The D.O. in charge of the work was Major E. A. H. James.

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Mr. Palmer and the R.E. crew under Serjeant Gough, R.E., reported at Tidworth on the evening of the 6th of May.

The drilling plant (supplied by the S.M.E., Chatham), consisted of a "Star" pattern well borer of the percussion type.

Boring was begun on Friday, the 9th of June, and water was reached 325 ft. above O.D. on the 19th of June. Sand was reached at 428 ft. from the surface (22 ft. above O.D.), on the 21st of July. This sand, though not of normal appearance, was presumed to be the green sand, a presumption which has since been confirmed by the Geological Survey, and it was decided to test the yield of the bore at this depth before considering the necessity of going any deeper. The number of days on which boring had taken place was 18, and the greatest depth bored in a day of eight hours was 50 ft. The remainder of the time between the 9th June and the 21st July, namely, 12 working days, had been spent as follows :—

Tool dressing	3 days
Making cutting shoe and sinking casing ...	5 ,,
Delay owing to defective belt	2 ,,
Repairs to drilling plant	2 ,,
	12 ,,

Saturday mornings were spent in cleaning down plant, men's quarters, etc.

The bore was lined to a depth of 181 ft. The strata bored through were chalk, with various proportions of flint and with indications of a great deal of clay shortly before reaching the sand.

Tests were carried out with a Lacey Hulbert air compressor obtained from the R.A.O. Depôt, Woolwich.

This compressor gave 130 cub. ft. of free air a minute, and was run at a maximum pressure of 125 lbs. per sq. inch.

It arrived on the 15th of August, but, owing to the delay in the arrival of special fittings which had to be purchased, no test could be made till the 6th of September. The compressor was fitted up in the old Pumping Station at Chalk Pit, and 672 ft. of 6-in air pipe was laid from the compressor to the bore, the intention being that the large-size pipe would act as an air container. For the first test a 6-in. rising main was used with a 2-in. air pipe inside. The submergence ratio was rather over 60 per cent. Water was brought to the surface between the rising main and the bore.

A 4 in. × 1 in. air lift was substituted for the 6 in. × 2 in. In taking out the 6-in. rising main, two lengths were left at the bottom of the bore owing to a faulty thread giving way. These lengths were later very neatly and quickly recovered by Mr. Palmer by means of a conical wooden plug dropped into the 6-in. pipe and left

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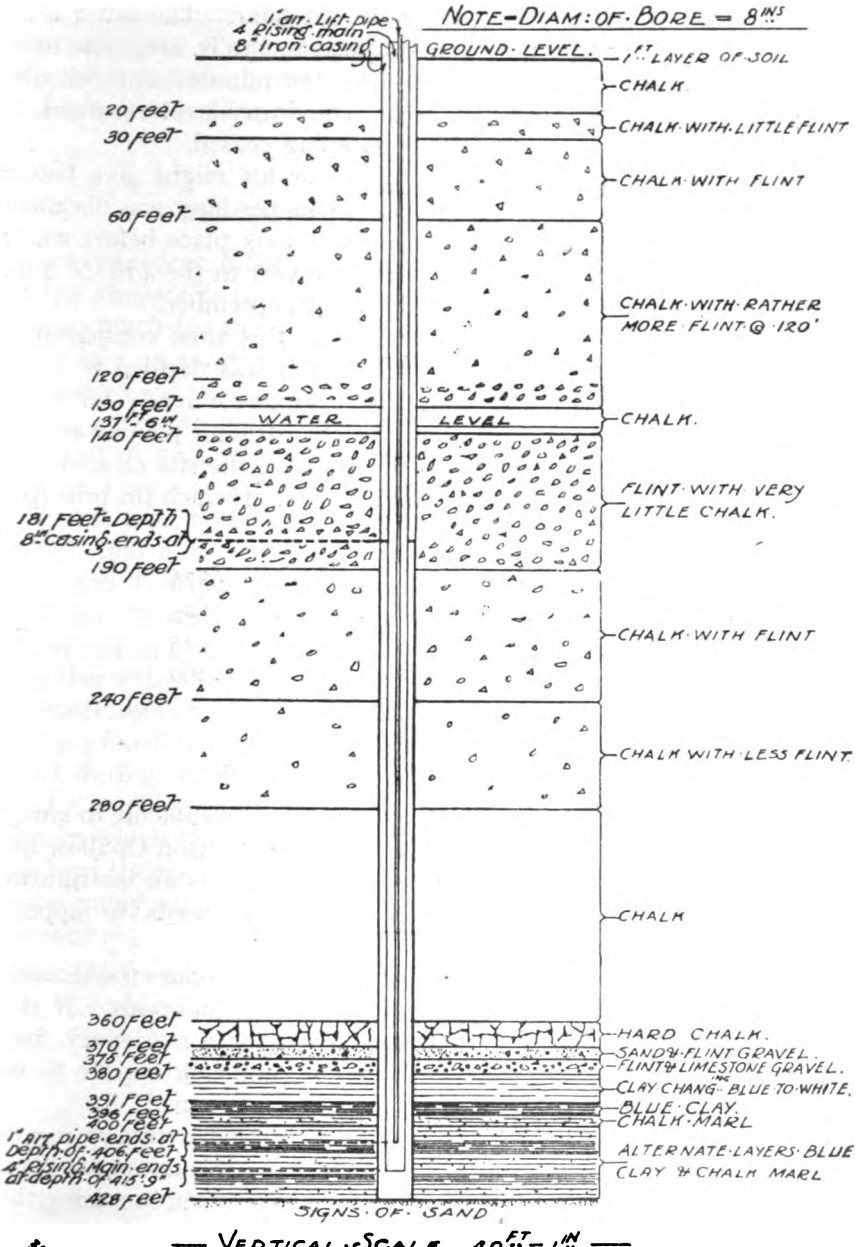
TIDWORTH

NEW WELL BORE HOLE NEAR CHALK PIT WELL

SECTION SHOWING STRATA & DEPTHS OF BORING CASING ETC



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to swell for 24 hours. The next test was carried out with a 4-in. × 1 in. air lift. The bottom of the rising main was 417 ft. from the surface and the bottom of the 1-in. air pipe was 404 ft. from the surface. The starting pressure was 125 lbs. and the running pressure 105 lbs. per sq. inch. The test lasted twenty minutes and water was obtained at the rate of 5,000 galls. per hour. The water level at starting was 137 ft. 6 in. This dropped to 170 ft. after one minute's run and rose again to 165 ft. after ten minutes' run (all distances measured from the surface). The water-level returned to normal level twenty minutes after pumping ceased.

It was thought that a 4 in. × 1½ in. air lift might give better results. A flow at the rate of 11,000 gallons per hour was obtained for 2½ minutes, then a pause of 4½ minutes took place before water started flowing again. It was decided to revert to the 4 in. × 1 in. pipes, and they were replaced by the 22nd September.

The water-level at Chalk Pit Well was at this time considerably above that at the same date in 1921, and it was decided to cease work, but to leave the bore and the compressor ready for work in case the necessity should arise. The drilling plant was dismantled, all spare piping returned to store and the site cleared.

The total cost of the work was under £700, of which the principal items were as follows :—

Civilian Labour	£275
Fuel	£25
Transport, etc.	£25
Material	£360

THE ELVERSON OSCILLOSCOPE.

WHEN mechanism is operating at high speeds, it is difficult to study any fault in the movement of the parts. The Elverson Oscilloscope (described in *Engineering* of 8th December, 1922) is an instrument which enables mechanism running at normal speeds to appear slowed down or stopped.

The operation can easily be understood if one imagines the seconds hand of a watch viewed by flashes of light at intervals. If the flashes occur every minute, the hand will appear stationary, but if they are at a slightly less interval, the hand will appear to be moving very slowly in a counter-clockwise direction.

In the Oscilloscope, the illumination is provided by an incandescent bulb filled with neon. The ordinary incandescent lamp is not suitable, as, with it, an appreciable time is taken in raising the filament to incandescence and cooling it down again.

The contact-breakers which regulate the illumination are operated by the mechanism being studied, through gears. There are two

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distinct gears provided, one of which gives the exact speed of the mechanism to the interrupter, and the other a speed one-hundredth or one-thousandth less. The use of the first enables a " stationary " examination to be made, while the second gives an apparent motion of one-hundredth or one-thousandth of the actual value.

Any mechanism can be studied by this instrument, and by its use faulty gear wheels, bouncing action with cams, lag in the closing of valves, and so on, can easily be detected. It has further uses in crankshaft balancing and the measurement of torsion in a shaft.

C.C.A.

Fastenings for Portable Structures.

The experiences of the recent war have proved that hutted buildings of the *démontable* type are, in certain situations, of immense value, not so much for the reason that such huts can be dismantled and re-erected on a new site, but rather because the initial erection can be carried out in a minimum of time and with no skilled labour.

The parts can be made in workshops in England and shipped to the seat of war, where they are held ready for erection as soon as the need for a new hospital, depôt, or other camp may arise.

In the past, the majority of such huts have been of the " panel " type ; that is to say, they are made with the walls, and often the roof and flooring, in sections, or panels, which could be bolted together, the use of bolts enabling the hut to be rapidly dismantled when necessary. Some of the German sectional huts are fitted together with steel clips, but these are liable to damage in transport.

Panel huts are usually supplied with the covering and floor-boards already fixed, to save time in erecting and to keep the various sections rigid during transport.

If a portable hut could be designed in which there were no panels, but in which the wooden members could be fitted rigidly together without the use of nails (which makes dismantling difficult), it would have many advantages over the " panel " type, for the following reasons :—

1. The members could be " bundled " and so a good deal of space economized in packing.
2. Each hut could be in a separate bundle. There would then be no risk of some vital part going astray. With panel huts, all the panels of one type (*e.g.*, floor panels) are usually packed together to save space, and these may easily get separated from the " roof " and " wall " sections.
3. In many situations, covering material is not required to be sent out from home, as it is obtainable locally. If panels are not covered they must be crated or boards nailed across, to keep them in shape during transport.

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4. Panels easily get out of shape and damaged.
5. Damage to one member of a panel may make the whole panel unserviceable.

A portable hut with separate wooden members has not been found satisfactory in the past owing to the impossibility of making the hut sufficiently rigid without complicated scarf joints for fixing together the sections of the top and bottom rails which run the whole length of the building. Further, there are practical difficulties in bolting the various members together.

A new fastening has recently come on the market which may be useful for the type of hut which has just been described. This is called the "Steelgrip" fitting and is illustrated in *Figs.* 1, 2 and 3. It was originally designed for bedsteads and portable furniture, but has been found useful for very many other purposes, where wood or metal members have to be fastened together and disconnected later, and when the fastenings need great strength and rigidity.

These fittings are stamped from sheet steel. The two parts of the fastening are called the post plate and the rail plate respectively. *Fig.* 1 shows the back of the post plate or "tongue" fitting, which is fixed by screws so that the tongue fits tight against the framework. *Fig.* 2 illustrates the front of the post plate with counter-sunk holes for screws. The post plate is made of two superimposed stampings which are spot-welded or riveted together, but in some of the smaller patterns, one stamping is used and folded over. *Fig.* 3 shows the rail plate or "slot" fitting which is in one piece. The complete joint secured to the woodwork and assembled is shown in *Fig.* 4. In the fitting illustrated, the rail end must be grooved to provide a passageway for the post plate, but another pattern avoids the necessity for the grooving by having turned over flanges at the sides of the rail fitting, which provide a passage for the post plate.

The fittings are made in sizes ranging from $\frac{1}{2}$-in. to 6-in., stepping up by quarter inches. The metal is a good quality of mild steel which may be finished black, plated, or rendered rustless by some process such as sherardizing. Rustless steel may be used. The fittings can be attached to wood by screws, or to metal by riveting or spot welding. When fixed, they occupy very little space and there are no projecting parts which are liable to be broken in transport.

The two members are locked instantaneously, and a blow from a mallet is all that is required to dismantle. When locked, the joint is extremely rigid, and has great strength in every direction (except that in which the dismantling takes place). In cases where there may be a risk of the fitting working loose in the direction of dismantling, a nail half-driven into the woodwork after assembly will prevent this. No tests have yet been made of the ultimate strength

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"STEELGRIP" FASTENING FOR PORTABLE STRUCTURES.

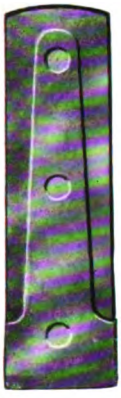

FIG. 1.

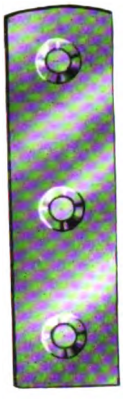

FIG. 2,

FIG. 3.

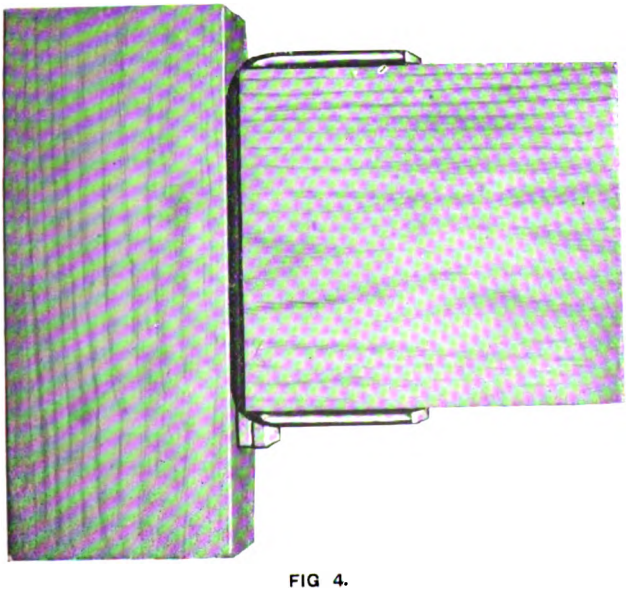

FIG 4.

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of the joints of various sizes, but it is probable that the wooden members will be found to fail before the joints.

In addition to portable buildings, there are many uses to which these fittings may be applied where strong and rigid joints are required, and where rapid assembling and dismantling are needed. Possible military uses include portable furniture, movable shelves and racks, portable latrines, ablution benches and meat safes.

The fittings are obtainable from the "Steelgrip" Fittings, Ltd., of 32 Alfred Place, Tottenham Court Road, London, W.C. 1.

C.C.A.

Storage and Transportation of Portland Cement.

The deterioration of Portland Cement during transportation and storage has been thoroughly investigated recently by the United States Bureau of Mines, with the object of discovering a means of preventing it. The results are given by Mr. W. M. Myers, Assistant Mineral Technologist of the U.S. Bureau of Mines in *Engineering* of December 1st, 1922.

This deterioration is due to partial hydration by absorption of moisture from the atmosphere, and the amount of deterioration varies directly with the degree of hydration. This depends naturally on the time of storage, but during transportation varied climatic conditions may be met, which will have a bearing on the deterioration.

Experiments have shown that cement stored in a shed in cloth sacks may lose 20 per cent. of its original strength after three months' storage, 29 per cent. after six months, 39 per cent. after one year and 60 per cent. after two years. These figures point to the necessity of using cement as soon as possible after it has been ground.

Deterioration is minimized when the cement is stored and transported in bulk, but for small quantities, the use of barrels is much better than bags or sacks, which give undue exposure to the air. Further, sacks are difficult to handle, and liable to be torn by hooks, thus exposing the cement directly to the atmosphere.

The possibility of storing and transporting unground clinker and grinding it at its destination is also discussed, but this project would obviously only be practicable where very large quantities are required.

C.C.A.

New British Standard Rolled Steel Sections.

The original list of British rolled steel sections published by the Engineering Standards Committee in July, 1904, has been revised, and a new list of *British Standard Rolled Steel Sections for Structural Purposes* (*Revised July*, 1920) is now obtainable, price 1s. (Crossby, Lockwood & Son). The new sections are designated N.B.S.B. (New

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British Standard Beam), N.B.S.U.A. (New British Standard Unequal Angle), etc., and, owing to the omission of the less commonly used sections and the insertion of certain new ones, the numbering throughout each series has been materially altered.

The main differences between the two lists are in the dimensions of the beams and channels. These alterations have been introduced in consequence of the fact that modern rolling mills are able to produce sections on a commercial scale which approach more nearly to the theoretically perfect profile. The thicknesses of the webs have in most cases been reduced and in some there is a corresponding increase in those of the flanges. A new series has been included in the revised list called *Heavy Beams and Pillars* (N.B.S.H.B.) which consists of wide-flanged beams primarily intended for use as struts and columns. It should be noted that, except for the fact that all the web and flange thicknesses have been changed, it is only the three heaviest beams in this list that do not occur in the old series. A later publication in August, 1921, contains the moments of inertia and other properties (in both British and Metric units) of the new beams and channels.

The new equal angles (N.B.S.E.A.), unequal angles (N.B.S.U.A.) and Tees (N.B.S.T.) are the same as the old sections except for small changes in the radii of the corners. Many uncommon sections have been omitted, but very few additions have been made A certain number of standard thicknesses are still adopted for each section, but other thicknesses can be ordered if required. The properties other than the dimensions and sectional areas of the new angles and Tees have not yet been published, but can be obtained with quite sufficient accuracy from the old list

It will, of course, be some years before the rolls for producing the old sections are worn out and existing stocks expended, but it is worthy of notice that most large firms are already prepared to supply the majority of the new sections. By specifying the new channels and beams there is no doubt that an appreciable saving can be made in steel structures owing to the more economical shape of many of the profiles.

E.F.T.

SURVEY.

By Colonel H. ST. J. L. WINTERBOTHAM, C.M.G., D.S.O.

SINCE the war surveyors throughout the Empire have been busy on somewhat curtailed programmes. Some very interesting maps have been received, none the less, particularly from the Gold Coast, which is beginning to inaugurate its own printing establishment. The last field season has produced an excellent output, and it is a little

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difficult to say whether to congratulate more heartily His Excellency the Governor of that colony on his survey establishment, or the survey establishment on its governor. In the Federated Malay States there is a considerable programme of work for the future which should occupy the staff for some twenty odd years. Meantime, they have produced, amongst others, a map at eight miles to the inch, showing administrative features and relief in brown hill shading. The War Office is arranging for the printing of several sheets for Uganda, which help to fill up a rather wide gap in our mapping of East Africa, and Trinidad is now being surveyed. One can only hope that other West Indian communities will follow suit. In one recent case (1920), a map of a colony made in 1806, and republished with corrections in 1824, was reprinted as it stood. The maps of foreign stations in which garrisons are maintained are, one by one, being gridded in the system which is sometimes called "Lambert's" and sometimes "the French." It did so happen that the French were using it, at the time of its adoption by the Allies, on maps constructed on a Lambert conical orthomorphic projection, but the grid is not a legacy from this famous old mathematician, neither does it follow precisely the form in which it was used by the French. The process of fitting the new grid on to old maps is not without its sad moments. One discerns many discrepancies between trigonometry and topography.

The International 1/1,000,000 map which Sir Charles Close rescued in 1909, from the stage of international discussion and placed upon a practical and working basis, continues to make steady progress. There are now 40 sheets of this International Map published, nine of which appeared in the period of the 1922 Report. The outstanding feature of this report is its witness to the size and value of India's contribution. The International 1/1,000,000 Map has exerted a good deal of influence upon the small scale map of to-day. For example, the 1/2,000,000 maps of Africa which are being produced by the Geographical Section of the War Office, in collaboration with the Service Géographique de l'Armée of Paris, are based upon the international projection and sheet lines, as is also the War Office 1/4,000,000 of Asia, of which several sheets have already appeared.

In 1919, the International Committee on Aerial Navigation began its work and entrusted the making of maps suitable for airmen to the hands of a sub-commission. This sub-commission is following the sheet lines of the International 1/1,000,000 Map, but not the projection, for which it has adopted the Mercator. At first sight the adoption of this projection, which has been used so largely and so unsuitably by the Atlas makers of Great Britain, was resented by the geographical world. The matter was discussed at the last meeting of the British Association for the Advancement of Science,

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but as the audience at that time was not prepared to criticize the proposal in detail, a discussion at the Astronomical Society was held on the 2nd February. This discussion was opened by Colonel Jack (Director-General of the Ordnance Survey), and it was presently realized that the problems of aerial navigation and the express desire of those engaged in it had made the decision a matter of necessity. The Sub-Commission for Aeronautical Maps has recently approached the Central Bureau of the International 1/1,000,000 Map, which is situated at Southampton, in the Ordnance Survey buildings, with a view to securing its services as an intermediary between itself and the nations which adhere to international aeronautical agreement. These international air maps consist of a series known as the "general," on the Mercator projection which we have mentioned, and at a scale at the equator of 3 cm. to one degree of longitude, and of another known as the "local," at some much larger scale. For these "local" maps the idea is to take the suitable survey of the country in question, which would be the ½ in. to 1 mile in England, or the 1/200,000 in France, and to publish it in a form suitable for use from an aeroplane. The Geographical Section of the General Staff is engaged on preparing samples of the sheets of both "general" and "local" series, as approved by the Sub-Commission. It is a matter of some amusement, endeavouring to cater for the general taste of airmen. No two of them appear to look at country in precisely the same way and when, after repeated efforts, a map had been made, of which the Sub-Commission for Aeronautical Maps approved, a private letter was received from a distinguished foreigner who said that he could make neither head nor tail of it from the air. No doubt, it will take many years before we come to the final form. Meanwhile, after repeated meetings, a measure of agreement has been reached and some of the more important sheets, covering important flying routes, are to be published.

Considerable interest is being taken now in the question of mapping from air photographs. One may say, indeed, that interest in this subject is re-awakening. During the war, survey from air photos had an abnormal development. Time was the essential factor and ground surveyors were naturally unable to penetrate the enemies' lines with impunity. The only answer then was to survey from air photographs. But immediately after the Armistice the future of this new method of survey was jeopardized by the over-confidence of those who understood little of its difficulties and of its relatively high expense. An experimental survey was carried out in India at Agra, which showed how little the problem of taking photographs in the most helpful way for the surveyor had been thought out by pilots. In fact, it soon began to be realized that it would prove very expensive to map from photographs as they were then taken,

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and for this reason no official British survey has made any definite movement in the matter. Areas of exceptional difficulty have, however, been done in this way. There was, for example, a survey of the Nile, in order to establish the periodical changes in channels, banks, etc., and there is a project afoot to map the Irrawadi Delta. At the instigation of Colonel Jack, a committee called the "Air Survey Committee," composed of members nominated by the War Office, the Air Ministry and the Ordnance Survey, was called into being in 1921, in order to discuss the future of mapping from air photographs, mainly, and naturally, with an eye to war. This Committee has evolved certain new cameras and instruments which are nearing the stage of practical experiment. It is hoped that they will provide the means of surveying and contouring a strip of country (say 50 miles wide), which is neither triangulated nor surveyed in any other way. The School of Aeronautics at Cambridge has also interested itself in the question and has tackled that side of it for which the navigator is responsible. In the course of its research, this school has arrived at very valuable conclusions and has now proved that an airman can, if he is properly trained, give us, not only single photographs, but strips of photographs with, relatively speaking, extremely small errors in scale and of distortion due to tilt. The Ordnance Survey have also found air photographs of value in their search for those archæological features which appear upon their maps. The present interest in this question is exemplified by the fact that no less than five lectures are being given this winter on the subject. Two of these lectures are to be at the Royal Geographical Society, one at the Royal Institution, one at the Royal Photographical Society and one at the S.M.E., Chatham. The conclusion that most surveyors are coming to is that photography from the air is so great an advantage for certain classes of survey that it must be employed. On the other hand, it is impossible to do without a triangulation, or some form of control, and in easy and hilly country topography on the plane-table goes so fast and so economically as to make its use inevitable. If we must have air photography, however, and we must also have the photographer to develop the photographs, and the surveyor to provide triangulation, and occasional topography, it will be necessary, probably, to combine these three in the person of a surveyor who can fly. One can imagine him in the future flying to his next observing station, photographing on his way home, and, perhaps, making a detour to cast an eagle eye upon any plane-tablers of whose zeal he may feel distrustful. The amount of transport, of mule flesh, etc., that the use of such an aeroplane would save, would, in itself, almost pay for its purchase and upkeep, providing that it were of a type which could be left out, if needs be, in any weather, or, at any rate, be taken to pieces and stowed away in some quite humble and cheap

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tent aerodrome. It is interesting to note that the Air Ministry is thinking seriously of the design of such an aeroplane at the present moment. The advantages to be gained in this way, shall we say, in the surveys of portions of Australia, would seem to make an experiment well worth the while.

In the instrumental world there have been one or two things of note. There was an exhibition of electrical, optical and other instruments at the Imperial College of Science in January. At this exhibition Messrs. Casella & Co. showed a micrometer theodolite in which the readings of the two micrometers were visible in the same eye-piece. In the course of an afternoon's observing it is quite possible that one may have to walk round one's theodolite some two or three hundred times in order to read both micrometers. Messrs. Casella & Co. are therefore to be congratulated on saving so much time. Messrs. Watts & Sons, of Camberwell Road, have produced a bubble which keeps an invariable length under all temperatures. I saw this bubble tested with a blow pipe. Curiously enough, its construction appears to be the happy result of a process of trial and error. Nobody, apparently, is in a position to state why it behaves in so amiable a fashion. No particular harm is done, however, if it really is invariable, and, if it is so, it means that it will be easy to add a mirror device which will show one end of the bubble in conjunction with a division of the scale. A touch on the screw, without moving position, will then bring it correct without having to proceed to a thorough re-levelling of the instrument.

From a scientific point of view, the fact of the greatest recent interest to surveyors is the appearance of the Ordnance Survey Report on the "Second Geodetic Levelling of England and Wales. 1912–1921." Since the days of Clarke no work of such geodetic importance has been published by the Ordnance Survey. That an undertaking of such national importance should have been begun, completed and described in print by one and the same Director-General is in itself a notable fact, but when one remembers the 4½ years of war effort which intervened, it becomes much more remarkable. The network includes three mean sea-level observatories—Newlyn, Felixstowe and Dunbar.

There is reason to believe, from the results of this levelling, that mean sea-level at Dunbar is several inches higher than it is at Newlyn, a fact due, at least in part, to general meteorological causes.

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MEMOIRS.

LIEUT.-GENERAL SIR JAMES BEVAN EDWARDS, K.C.B., K.C.M.G., COLONEL-COMMANDANT R.E.

IN Lieut.-General Sir Bevan Edwards, who died in London on 8th July, 1922, the Empire lost one of its builders whose work is too little known. A fine and distinguished type of the older order of soldier, with a record deserving of larger setting than it has yet received, the strands of his life were of the very texture of the Empire's story blended of the battle-field and the Council Chamber. Far-sighted and progressive, keen in all he undertook, fearless in the acceptance of responsibility, warm-hearted and loyal, his directness of speech reflected his strength of character as surely as innumerable acts gratefully remembered reflected the tenderness of his nature. Those who at times opposed him most were among those who loved him most. To all who knew him well he leaves cherished memories of cheery comradeship and ideals stoutly fought for.

Sir Bevan was the son of Samuel Price Edwards, of Buncrana, Co. Donegal, at one time Collector of Bombay.

He was born on 5th November, 1834, and was educated at a school on Shooter's Hill and at the Royal Military Academy, Woolwich, where he became Senior Under Officer and distinguished himself in athletics by winning a two-mile race. He received his commission in the Royal Engineers on 22nd December, 1852, and, after the usual period at Chatham, was sent to the Isle of Wight, and was employed on the projects of the defences of Freshwater, under Major-General Sir Frederick Smith, C.R.E., South Western and Sussex District, from whom he received generous praise in a C.R.E.'s Order of 11th July, 1855, when he and Captain (afterwards Sir Lothian) Nicholson left England for the Crimea. It had naturally been a matter of considerable disappointment to young Edwards that he was not sent out in the earlier days of the struggle, and even now he met with so many unfortunate delays on the voyage that he did not land in the Crimea until after the fall of Sebastopol. He was, however, fortunate enough to be employed on the demolition of the docks, where he came under Russian artillery fire, and in due course received the Crimea and Turkish medals. In June, 1856, he was moved to Corfu and spent an enjoyable time

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shooting and yachting, making trips to the neighbouring islands and to the mainland in Albania. On hearing of the outbreak of the Mutiny in India he hastened home on leave, *via* Trieste, and, volunteering for active service, was posted to the 21st Co., Royal Engineers, with whom he landed in Bombay in November, 1857. The Company received orders to join the Central India Field Force under Sir Hugh Rose. While marching towards Mhow the Officer Commanding the Company, Captain G. Neville, was killed near Ratgurh by a round shot and Edwards received the command. He took part in the siege and storming of Chaudairee, for which action he was mentioned in dispatches, and in the battle of the Betwa. In the storming of the city of Jhansi on 3rd May he was in charge of the ladders of the successful left escalading column. After the fall of the city the Force marched to the Jumna and met with further resistance at Koonch, Goolowlee and Calpee. It was then broken up, but the 21st Company saw further service under Sir Robert Napier at Gwalior and in the pursuit and capture of Tantia Topee, who for a time was a prisoner in their quarter guard, as they were the only Europeans employed in the pursuit. For his share in the suppression of the Mutiny Edwards was three times mentioned in dispatches and received the medal and clasp, the brevet of Major in 1860 and the C.B. in 1877. In Sir Hugh Rose's dispatch of 18th April, 1858, the following extract, referring probably to the battle of Betwa, is worthy of quotation :—" The enemy, simultaneously with their attack on my right, had advanced with equal vigour against my right centre, guarded by part of the 25th Bombay Native Infantry, who, despite a most gallant resistance, were driven back by over-powering numbers, which afforded an opportunity to Lieut. Edwards, commanding the 21st Company of the Royal Engineers, which I had placed in support of the 25th, to charge with his Company, most successfully, the very superior force of the rebels, routing them with loss and pursuing them till out of reach. . . . The 21st Company fight as well in the field as they work in the trenches, and are worthy of their distinguished Corps." At the end of hostilities the Company was ordered to Dagshai, and from July to December, 1859, Edwards spent six months' leave on a tour in Thibet, Ladak and Kashmir. He travelled from Simla northwards to the Indus, and shot yak and ovis ammon near the Pangong Lake ; he then journeyed through Leh to Srinagar and, after spending some time shooting bear and bara singha in Kashmir, he returned to Dagshai *via* Chamba. Soon after this he was ordered home. At Calcutta he found Sir Robert Napier preparing his expeditionary force for China, but Sir Robert told him that there was little chance of fighting, so that he made no attempt to cancel his orders and duly arrived in England, where he was at first employed at the War Office and later to the command of the 2nd

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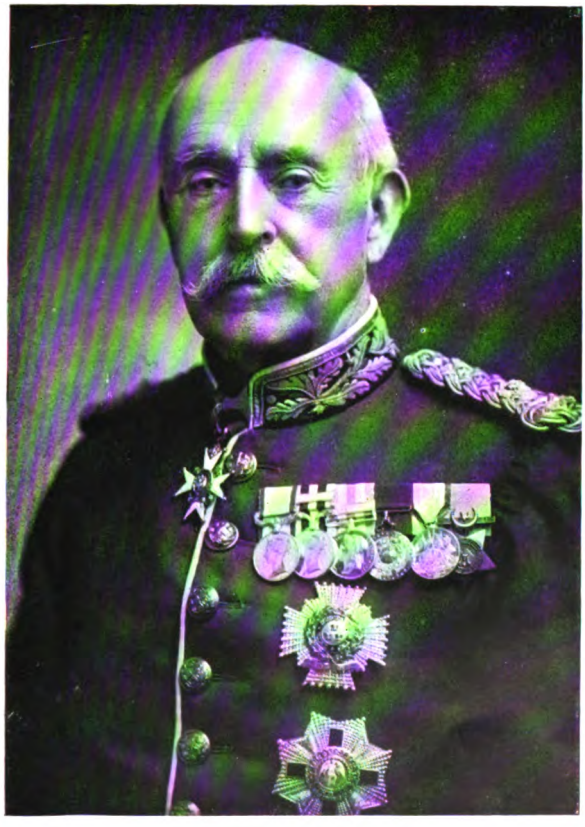

Yours sincerely
J. Bevan Edwards.

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Company R.E. at Aldershot. In 1863 he was ordered to Canada, but exchanged into a company under orders for China, and arrived at Hong Kong in December after a five months' voyage round the Cape. Pressing on to Shanghai he joined Gordon's Ever-Victorious Army in time to take part in its last sanguinary action, the siege and capture of Chang Chowfu, for which he received a gold medal. He remained in the neighbourhood for some time, employed on survey work, and later made an interesting tour to Tientsin and Pekin and to the Great Wall before he returned to Hong Kong. In 1866 he returned to England and became Major of the Training Battalion at Chatham. About this time Major Edwards published a pamphlet suggesting " An Organization for the Army of England." Space will not allow of even a short summary of his proposals, but they included the concentration of a larger number of battalions in England, their organization with other troops into *corps d'armées*, short service during wartime, the formation of depôts and facilities of expansion from peace establishments. A letter exists from Sir John Burgoyne in which the veteran Field-Marshal, still in harness at the War Office, gives his opinion of the proposals. " It is a very important question, and one of very great difficulty, and on which you enter into competition with many others. . . . My feeling is, what you all appear afraid to meet, that *additional* means are among the things needful, and *additional* expense will be necessary to make us secure against the enormous preparations making in the rest of the world . . . your arguments about the Colonies may be true in the abstract, and that many *should* defend themselves, but it has not yet been so *decided*, and they look to us to protect them ; and when the emergency arrives they will cry ' Shame ! ' upon us not doing so."—An interesting comment in view of the important part played by Sir Bevan in later years towards making some of the greatest of the Colonies self-defensible. In 1868 he lectured upon the same subject at the Royal United Service Institution and in 1871 he published another pamphlet, *A National Army, or How to Solve the Problem of To-day*, in the preface of which he was able to say that " since the following pages were printed Mr. Cardwell, as Secretary of State for War, has brought forward in the House of Commons the new scheme of Army reorganization proposed by the Government, the main features of which tend towards the fulfilment of the proposals put forward in this pamphlet," and, he might have added, in his previous publications. At the end of 1867 he was selected to escort a Japanese prince on a month's tour in the British Isles, and after that he was moved to Portsmouth, where he remained for ten years. In 1868 he married Alice, daughter of R. Brocklebank, who died in 1899. In 1871 he became Lieut.-Colonel by brevet. In 1877 he was sent by Sir Lintorn Simmons, then Inspector-General of Fortifications,

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on a secret mission to select a harbour suitable for a coaling station between Malta and Port Said. It has been explained recently by Lord Sydenham that Sir Lintorn was opposed to the Prime Minister, Disraeli's, policy of annexing Cyprus, and sought for a harbour, which would entail less responsibility and expense. Edwards' instructions suggested the harbour of Tristoma in the island of Scarpanto, or Symi Island, near Rhodes. He sailed in H.M.S. *Salamis*, Commander F. W. Egerton, R.N., on 4th May, and, after calling at Malta, examined and reported upon the two harbours already mentioned, but selected as more suitable Port Vathy in the Island of Stampalia. Needless to say, Sir Lintorn did not succeed in converting the Prime Minister to his views, though, as Lord Sydenham writes, it is doubtful if Cyprus was of any real use to us.

In October, 1877, Edwards was promoted Lieut.-Colonel and Brevet Colonel. He served for short periods in the Northern District and at Shorncliffe, and had spent some time on half-pay when in February, 1885, he was sent to Suakim as Commanding Royal Engineer of the Suakim Field Force, under the command of Sir Gerald Graham, V.C. He was present at the action of Hasheen, the attack on Convoy on 26th March, and the action of Tamai. Sir Gerald's dispatch does justice to the unfailing assistance rendered by his C.R.E. in carrying out the many engineering operations which had to be undertaken, including the construction of zarebas, forming defensive posts at various places, the clearance of dense bush, formation of ground for the railway and development of the water-supply. The services of the balloon detachment, under Major Templer, which, however, were generally baffled by the high wind, received notice and also those of the telegraph service, and the fighting of the 17th and 24th Companies, R.E., and of the Madras Sappers, at MacNeill's Zareba on 22nd March, where, in spite of heavy losses, they contributed to the heavy defeat of the enemy. The campaign was over in June and Colonel Edwards returned to England, and, having received the substantive rank of Colonel, was appointed Commandant of the School of Military Engineering at Chatham, a post which he held until March, 1888, soon after his promotion to Major-General. Many of the officers of the Corps who distinguished themselves in the Great War received their early training during his period of command, and these remember him as an admirable Commandant, keen on work, keen on improving the organization of the S.M.E., and also a keen lover of cricket, who repeatedly played in the S.M.E. XI and could be counted upon to make a few runs and take a wicket or two in every match. In March, 1889, General Edwards took up the command of the Troops in China, but he remained in Hong Kong for only a few months, as his services had already been asked for by the Colonial Office to

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inspect and report upon the local forces of the Australasian Colonies and to advise the respective Governments as to the uniform organization of these forces with a view to mutual co-operation on emergency. The orders to carry out this duty reached him at Hong Kong in May, he arrived at Brisbane in July and his Report on the six colonies of Australia was dated from Sydney in October. After reporting separately upon the conditions which he found existing in each colony, he concluded with his proposals for their organization for joint action, in which he recommended that there should be a federation of the forces, under a Lieut.-General, a common system of organization and armament, a common Defence Act, a federal Military College for the education of officers, a federal Small-arm Factory, Gun Wharf and Ordnance Store. Rifle Clubs should be extended and a uniform gauge of the railways instituted. Each colony had small Permanent Forces of garrison artillery and submarine miners, and these he proposed to amalgamate into a uniform "Fortress Corps." In the course of his tour General Edwards was brought into contact with many of the leading colonial statesmen, and it is certain that his earnest conversations and letters added considerable weight to the movement in favour of the federation of the colonies. At any rate, his visit did much to clear the air and to inculcate sound principles of defence. A month later he had completed his inspections in New Zealand, where he recommended the amalgamation of the districts into four and the organization of field forces, "small in peace, but capable of great expansion in war," in each district. For domestic reasons he was obliged to resign the command in Hong Kong in the following spring (1890) and was not employed again. In 1891 he became Lieut.-General and K.C.M.G., in 1903, Colonel Commandant of the Royal Engineers, and, in 1912, K.C.B. He represented Hythe in Parliament from 1895 to 1899. In 1901 he married Nina, daughter of John Balfour, of Steephurst, Petersfield, and widow of Sir R. Dalrymple Elphinstone, who died in 1916, and, in 1918, he married Amy Ann Courtenay, daughter of the late J. N. Harding, of Buzzacott, N. Devon. The activities of his later years were devoted whole-heartedly to the service of the Imperial Institute, in which he held the office of President of the Council from 1909 to 1915. One who was closely associated with him in this work writes: "He spent his life as an Engineer in matters civil as well as military; he wanted to get things done; keenly conscious as he was of the necessity and utility of propaganda, he was chiefly concerned with results. Material—political or physical—existed for him only to be used for construction. . . . The secret of his success is to be found partly in his capacity for work, partly in his power of organization and de-centralization. . . . He never spared himself, but he imposed upon others the performance of the tasks which he regarded

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as peculiar to their office. He indicated the object to be kept in view, he was prepared always to advise and superintend, and the manner in which he got things done by committees, colleagues and subordinates, was the best tribute to his genius for organization."

F.E.G.S.

COLONEL FRANCIS JEREMY DAY.

THE death took place in London, on 13th November, 1922, of Colonel F. J. Day, late R.E., who from January, 1884 to June, 1889, held the appointment, then an active one, of Secretary of the R.E. Institute, and Editor of this Journal. Colonel Day was born in 1846, he received his first commission in 1868 and retired as a Brevet Colonel in 1899. His last appointment was that of C.R.E., Guernsey. He was not fortunate enough to take part in any of our little wars; indeed, his only foreign service consisted of comparatively short periods at Bombay and Ceylon. Colonel Day married, in October 1871, Sarah, third daughter of the Ven. Archdeacon Randell, Vicar of St Mary Redcliffe, Bristol, and his three surviving served in the war. He will be remembered as a zealous and painstaking officer and a genial and kindly companion. The files of the old foolscap *Pickaxe* bear testimony to his industry as an editor, and members of the Institution may remember with gratitude that his generous services on their behalf on various committees ceased only as recently as in 1921, under the pressure of his last fatal illness.

F.E.G.S.

COLONEL CHARLES KNIGHT WOOD, O.B.E.

COLONEL Charles Knight Wood died on the 12th instant, after a short illness, at Bodenham, Herefordshire, aged 71 years; and was laid to rest by his wife at Humber Church.

From his boyhood he was a remarkable athlete, excelling in running, jumping (his best was 21 ft. 7 in.), Association football, cricket, lawn tennis and other games and sports, a good horseman and expert canoeist. He and Von Donop formed a redoubtable wing pair in the R.E. Officers' team which carried all before them in the early seventies, finally winning the Association Cup for All England. He was a fine and versatile actor and had artistic tastes and pursuits.

A few days before he was taken ill with broncho-pneumonia he had been taking, with his customary success, the leading part in a play, produced for a charity, at the Kemble Theatre, Hereford.

He entered the R.E. in January, 1872, and retired in December, 1904, serving abroad in Bermuda, Malta, North and South Africa.

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Colonel C. K. Wood, Retired, R.E.

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In the Soudan War of 1885, he did fine work on the Telegraph Service : eventually, on the illness of other officers, having charge of about 1,200 miles of line.

At the outset a very important and urgent matter had to be settled on which the military and civilian Telegraph authorities held distinctly opposite views. The day after his arrival in the country, which was entirely new to him, " C.K.," as he was always known and spoken of, started up the Nile on a donkey to inspect the wires and offices, putting up with sheiks, covering 42 miles in one day on his donkey, and conclusively establishing the military view, which was fully confirmed by the later war experience.

In the Boer War he served in Natal, under Sir Redvers Buller, who appointed him Chief Engineer to his Force ; and on two occasions Sir Redvers said to the present writer : " Your brother has done me right well—right well." He received a Brevet Colonelcy for his services.

After he had retired, Colonel Wood was appointed Secretary to the Herefordshire Territorial Association at its initiation and only gave up this work when he was past 70.

During the Great War he did hard and valuable work—in fact, during his whole life he put his whole heart into whatever he had to do.

C.K. was very enduring : in his 52nd year he bicycled 162 miles across England by a route he had never travelled.

Ever cheerful and kindly, his influence for good in his parish—both religious and social—was very marked : indeed, his vicar in speaking of him said : " He was father and brother to me, and fellow-worker."

He was loved by many friends near and far, and a blank is felt in not a few houses. The Bishop of Hereford in writing of him said " The influence of such a man is of the highest value to the whole neighbourhood. He will be grievously missed ; his genial manner and sterling character had won him respect, and, indeed, affection."

E.W.

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CORRESPONDENCE.

THE EMPLOYMENT OF DIVISIONAL ENGINEERS IN CONJUNCTION WITH OTHER ARMS IN WAR.

A Lecture by Bt. Major G. E. H. SIM, D.S.O., M.C., *p.s.c.*, R.E.

To the Editor, R.E. JOURNAL.

SIR,

In the interesting lecture, entitled as above, reproduced in the December number of the *R.E. Journal*, there is a debatable point affecting co-operation of the Royal Engineers and their most recent offspring.

The system of providing good intercommunication for divisional engineers described, appears to be contrary to the general policy of intercommunication in the Army. It is stated that an "*independent* system of engineer communications" is necessary.

For efficiency in intercommunication, as in every other branch of engineering, certain principles must be adhered to. Two of these are Economy of Force and Avoidance of Divided Control. Any independent systems of intercommunication within a formation violate both these principles. The function of the Royal Corps of Signals is to furnish all requirements for intercommunication in the Army, except within units — in the case of R.E., within companies. If divisional signals, as suggested in the lecture, "cannot adequately supply" the needs of R.E., the matter should be put right by altering divisional signals. To give the C.R.E. and field companies permanently their own motor-cyclists must be uneconomical. Under most conditions there would be no useful work for them, unless "signals" were boycotted. On other occasions, other means of communication might be more effective. Messages, except between C.R.E. and field companies, might circulate partly by "independent" dispatch-riders and partly through divisional signals. Such a procedure would lead to confusion. Control would be divided.

As a normal practice, the "independent dispatch-rider," like the "direct telephone line" is undesirable. The extra men employed for such purposes would, if pooled with other personnel engaged on similar work, produce better results. There are occasions, however, when it is necessary to depart from the normal practice. A large proportion of the resources of divisional signals may be placed at the disposal of an individual commander. The arguments set out for divisional control of engineers apply equally to the control of the entire intercommunication system by O.C. Divisional Signals under the direction of the General Staff.

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The signal system of divisional artillery is cited in support of the "independent" system for divisional engineers. Artillery brigade signal sections form part of divisional signals and do not, as before the war, belong to R.A. Headquarters. This shows that the principle of independent R.A. signals is not intended.

The post-war establishments of divisional signals provide more personnel at divisional headquarters than older establishments. The solution to the problem appears to be *liaison* between the C.R.E. and O.C. divisional signals. The former would then be relieved of any anxiety about the transmission of his orders to field companies and their reports to him.

Yours, etc.,

H. C. B. WEMYSS, *Bt. Major, R. C. of S.*

Barrule, Woodlands Road, Camberley.

THE MATHEMATICAL CONCEPTION OF THE UNIVERSE.

To the Editor of R.E. JOURNAL.

SIR,

I read with great interest Colonel Mantell's article on "The Mathematical Conception of the Universe," in the *R.E. Journal* for December, 1922. May I point out, however, that Colonel Mantell appears to have gone astray as regards Einstein's interpretation of the Michelson-Morley experiment. He states that from the "experimental fact that light moves at one and the same velocity in every direction, regardless of the ether-flow, it is possible to show . . that every body which is in motion contracts along the direction of its motion." That is not so. On the contrary, the Michelson-Morley experiment shows that either

(*a*) The velocity of light is a constant for every observer, whatever his speed relative to the source of light (or, as Colonel Mantell puts it, that light moves at one and the same velocity in every direction regardless of the ether-flow; or

(*b*) That a moving body contracts in the direction of its motion.

Hypothesis (*b*) was put forward by FitzGerald and developed by Lorentz, as phenomena, such as the aberration of light, which were held to prove that the motion of light in the ether was independent of the earth's movement, seemed to rule hypothesis (*a*) out of court. This hypothesis, however, presents many difficulties, not the least being that of supposing that a body contracts by an amount depending only on its velocity and irrespective of its chemical composition and physical condition. Einstein, on the other hand, accepts (*a*) under the name of the "Principle of the constancy of the velocity of light," ignores the ether and only takes account of *relative* motion. According to him a body only *appears* to contract, to an observer in relative motion, and that irrespective of the motion of the body relative to the ether or to anything else but the observer. It is only in the case of an observer, on, say, the sun, who has measured the speed of light in his own system to be 186,000 miles per second, and the speed of the earth in its orbital motion round the sun as 18 miles per second, and therefore concludes

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the velocity of the ray of light, which he sees passing along the Michelson-Morley apparatus on the earth, to be 186,000 ± 18 miles per second; that it is necessary to assume a contraction, as the gain of velocity of 18 miles per second on the outward journey does not counter-balance the decreased velocity on the return journey. If this observer on the sun were aware that (as Einstein asserts) the velocity of light on the earth relative to Michelson is still only 186,000 miles per second, he would have no reason to suppose that there was any contraction.

To quote Professor Eddington (Romanes Lecture, 24th May, 1922): "The point is that every electron, at rest or in motion, is a perfectly constant structure; but we distort it by fitting it into the space-time frame appropriate to our own motion, with which the electron has no concern." The same applies to any material body.

J. S. BISSET, *Major, R.E.*

Sierra Leone, 8–1–23.

BOOKS.

HISTORY OF THE GREAT WAR.

Based on Official Documents. By direction of the Historical Section of the Committee of Imperial Defence.

MILITARY OPERATIONS.

France and Belgium, 1914.

Compiled by Brig.-General J. E. EDMONDS, C.B., C.M.G., R.E. (retd.) *p.s.c.*

Reviewed by Major-General H. F. THUILLIER, C.B., C.M.G.

THIS first volume of the official history deals with the landing of the B.E.F. in France, its advance to Mons and first contact with the enemy, the retreat to the Seine, and the battles on the Marne and the Aisne. It ends with the stabilization of the situation on the Aisne and the transfer of the B.E.F. to the left of the Allied line in Flanders. The opening movements of the latter are only given in outline, the full story being reserved for the next volume.

It is doubtful whether any other phase of the Great War will offer a story of more absorbing interest than this one, of which General Edmonds' narrative gives a clear, complete and vivid picture. There can be no doubt that the operations described will rank among the greatest achievements of the British Army. They were carried out under great disadvantages. The hasty mobilization and concentration resulted in the units being composed of reservists to the extent, on the average, of more than half their strength, and in their being hurried to the theatre of war before all ranks could resume their acquaintance with their officers and comrades or practice anew their duties as soldiers. The troops were immediately pushed by forced marches to the battle, confronted with greatly superior numbers of the most renowned army in Europe and called upon at once to undergo the severe ordeal of an enforced and prolonged retreat in the face of a more numerous and

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active enemy. They sustained this retreat for thirteen days, short of food and sleep when they began it and all through it. In numerous encounters with the enemy, both on the large and small scale, they more than held their own, hit him hard and marched away from him. At the end they were still an army, unbeaten and formidable. Then they turned in their tracks, advanced and took an important and decisive part in the battle of the Marne. Following up the retreating enemy to the Aisne they performed the remarkable feat of forcing a passage frontally, without possibility of manœuvre, across that river.

Truly does General Edmonds say " only those who have commanded British infantry can have any conception of what it can accomplish." These operations may be looked on as a crowning glory of the old regular army before it gave place to the great national levies called into being by the inspiration of Lord Kitchener. They were the culmination and fruit of the years of training and preparation that preceded the war. Other, more vast, more sustained, and even more critical, battles took place in later stages of the war, but to the participants in the retreat there is some quality of the essential drama of war which distinguishes these early operations from all the others and which makes those whose duty at that period held them elsewhere,

> " Think themselves accursed they were not there,
> And hold their manhoods cheap."

like King Henry's countrymen after St. Crispin's day.

Marshal Foch has said that great results in war are due to the commander and that history is right in making generals responsible for victory, and for defeat. To Sir John French, therefore, is due credit for the successful issue of these operations, carried through, as the narrative shows, under exceptional difficulties, arising, on the one hand from the instructions he received from the Government in regard to the necessity of avoiding serious losses, and on the other from the incompleteness of the *liaison* with the French armies with which he was co-operating. There were other factors, however, which contributed greatly to the issue. Of these the greatest undoubtedly was the resolute leading of the subordinate commanders and the steadfast courage and endurance of the rank and file. As General Edmonds says, " the soldiers astonished even those who had trained them by their staunchness, their patience, their indomitable cheerfulness under incessant hardship, and, in spite of a fire which no human being had ever before experienced, by their calm, cool courage at all times." But a study of the operations convinces one that even these qualities would not have ensured escape from the dangers that constantly threatened the force but for the presence of another factor, namely, the strategic blunders of the German leader, von Kluck.

Napier, in his *Peninsular War* is fond of quoting the maxim, " War is not a conjectural art," and of illustrating it by examples of commanders who acted on conjecture and were led to disaster. If there ever was a commander who treated war as a conjectural art it was surely von Kluck, and his senior colleague von Bulow was not entirely free from this tendency also. We know from von Kluck's own book that he laboured under the misapprehension that the B.E.F. had landed at

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Dunkirk, Calais and Boulogne, and that he was continually hoping, by turning movements, to cut off its retreat in the direction of those ports. This delusion continued to possess him till after the battle of Le Cateau. Day after day his orders show him bent on these encircling movements against an enemy whom he had failed to fix. At Le Cateau he conjectured that the British were facing east, whereas they were facing north, and after that battle he dispatched his cavalry and his 2nd Corps on a wide movement in a wrong direction on the assumption that the British would retreat westward and also gave Smith-Dorrien's Corps a twelve-hour start in its retirement southward.

These eccentric movements caused a gap between the First and Second German Armies and undoubtedly helped the B.E.F. to escape their foes. The subsequent action of von Kluck in ignoring the threat of Maunoury's Sixth Army and exposing his right flank to the B.E.F. as he moved south-east against the French Fifth Army gave the opportunity for his defeat in the battle of the Marne. All these matters are clearly brought out in General Edmonds' narrative, which explains the situations on the German side as well as on that of the British. The mistakes committed by the former are clearly exposed, but it cannot be said that a similar frankness is shown in regard to the British decisions. It will be a pity if the official historian is not permitted to comment at all on the wisdom, or otherwise, of the British strategic and tactical movements, since a history which criticizes one side and not the other must lack somewhat in balance. We should like to have had an impartial opinion on some of the points which have hitherto been obscure, such as:—Was General Smith-Dorrien justified in taking the risk entailed by standing and fighting at Le Cateau? Was Sir John French unduly slow in committing the British forces to the attack at the battle of the Marne? or, to take a case of minor tactics, how did it come about that the 1st Cavalry Brigade failed to picquet the heights overlooking its billets at Nery and so got a disagreeable surprise?

Although these cases are not judicially commented on, the description of the events brings out certain points we did not know before and furnishes the materials for forming our own judgments on certain matters. For instance, the situation during the night of 25th–26th August as it presented itself to Sir Horace Smith-Dorrien is given in detail. The gamble involved in his decision to stand and fight was an immense one. Was it unavoidable? We see now the state of disorganization in which the units of the II Corps arrived in the neighbourhood of Le Cateau during the course of that night, having been delayed all day by the congestion on the roads and the rear-guard fights with the closely pursuing enemy. We see that the position reached by the enemy's leading troops was such that the II Corps could not hope to continue its retirement without fighting unless it started before daylight. We see also that at 2 a.m. many units of the 3rd Division were only just coming in and that at 4 a.m. the rear-guard was only just arriving, dead-beat. We may therefore accept the conclusion that the decision to stand and fight was forced on the II Corps Commander by the circumstances. But one cannot help

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asking why he had to stand and fight *alone*, that is, without the support of the I Corps on his right.

The consequences of this isolated action were that a frightful risk was run of a disaster of the first magnitude. That this was avoided was primarily due to the mistakes made by the enemy. The German III Corps failed to press its attack on the exposed right flank of the British II Corps. The frontal attack was not maintained with sufficient vigour to prevent the defenders breaking off the fight, the pursuit was hesitating and slow and the German cavalry were sent in a wrong direction. These things saved the II Corps, but they accentuate the error that allowed one wing of the British Army to fight without the other.

Foch's dictum previously quoted is a sound one. When a failure occurs the cause may usually be traced in the orders or dispositions of the supreme commander. The British Army was caught with its wings widely separated when in contact with an enemy superior in numbers. We know that the original separation of the I and II Corps was due to the geographical conditions, *i.e.*, to the obstacle presented by the Forest of Mormal. But sound strategy would appear to dictate that once that obstacle was passed it was imperative that the two wings should at once be brought together again at all costs. Even had this involved a battle it would have been better to have a battle with the army united than to have one with only half the army, as actually happened.

The action taken was not well calculated to bring about a union. The decision that the II Corps should continue its retreat on the 26th in a south-westerly direction would tend to increase the gap between it and the I Corps, which was already some ten to twelve miles away to the north-east. The orders to the I Corps—directing it to the Busigny area—may have been conceived with the idea of effecting union,* but to carry them out the I Corps would have had to disengage itself from its contact with the enemy and make a flank march of 16 or 18 miles across the enemy's front. Such movements do not get done in war, and this one was not. The I Corps, instead of retiring S.W. on Busigny, retired south on Etreux and thus increased the gap between the two Corps to 18 miles. This gap was only slowly reduced day by day and did not finally disappear till the 1st September. All this time the British Army ran the risk of having one of its wings overwhelmed without being able to receive assistance from the other.

The oft-debated point as to whether the British Army was late in its arrival at the battle of the Marne, seems to be clearly brought out by this narrative. A distinguished Admiral, after reading it, summed up the question in a conversation with the writer of this review by saying :—" The British Army was evidently still going full speed astern when the French had begun to go ahead." This seems to state it quite accurately. If the British, on the morning of 5th September, instead of taking that last march in retirement towards the Seine, had

* O.O. No.8 directs that I Corps should connect with II Corps at La Sablière. Where is La Sablière ? None of the maps mark it. Even in this history we have not got the ideal map for illustrating a campaign, *i.e.*, one that contains *every* name mentioned in the text *and no others*.

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advanced, they would have gained 48 hours. If they had even halted they would have gained 24 hours. An examination of the clear maps and sketches illustrating the situation daily from 4th September onwards show what an opportunity was lost. Very likely they would not have progressed any faster than they did, as the resistance would have been greater, but they would have held and fixed the German II and IV Corps and enabled Maunoury to envelop their right flank.

If one should ask how it happened that the British Army was going astern when it should have been going ahead the answer is not easy to find. The order containing General Joffre's intention to advance only reached British G.H.Q. at 3 a.m. on 5th September, too late to stop the rearward march that day which had already begun (the great heat of the day had led to marches being carried out at this early hour). Sir John French is said, however, to have had an " inkling " the afternoon before. Was it enough to have warranted his arresting the retirement? Who can say? If we follow Foch's precept and put the responsibility on the supreme commander, we must put it on Joffre. He must have known of his own intentions, and if he did not make them clear to his ally till it was too late to stop the British movement, he cannot well be acquitted of responsibility for the result. In actual fact it was probably another example of the very imperfect *liason* between the Allied Armies which prevailed throughout these early days and was almost entirely overcome later.

There are numerous other problems of great interest which emerge from a study of General Edmonds' pages. The detail given in them is enough to give a very clear picture of the situation on any day, almost at any hour, yet the broad outlines are not blurred and we get a clear idea of the whole. Even if we wish that it had been possible to give the reasons why this or that action or decision was taken, we must admit that the manner in which authorities for the various statements are quoted gives one complete confidence in the accuracy of the facts stated. The succeeding volumes will not be in such detail as the first, but if they maintain the high standard set by it we shall be in possession of a history of the war which should combine authentic accuracy with human interest in an unusual degree for compilations of this nature.

THE NEW ZEALANDERS AT GALLIPOLI. By Major FRED WHITE, D.S.O., New Zealand Engineers.

THE NEW ZEALANDERS IN FRANCE. THE NEW ZEALAND DIVISION, 1916–1919. A popular history based on Official Records. By Colonel H. STEWART, C.M.G., D.S.O., M.C.

THE NEW ZEALANDERS IN SINAI AND PALESTINE. By Lieut.-Colonel C. GUY POWLES, C.M.G., D.S.O., from material compiled by Major A. Wilkie, Wellington Mounted Rifles.

(Printed and published under the Authority of the N.Z. Government by Whitcombe and Tombs, Ltd., Auckland, Christchurch, Dunedin and Wellington.)

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These volumes, which form part of the *Official History of New Zealand's Effort in the Great War*, have been presented to the Institution of Royal Engineers by the High Commissioner of New Zealand, and are a valued addition to the Corps Library at the Horse Guards. They are described as a " popular history " series, but they are more than this, and will all be read with great interest and instruction by military readers, as giving an intimate account of very many actions brilliantly and heroically carried out. As Earl Haig writes of the Division in a Foreword to the second volume, " Its record does honour to the land from which it comes and to the Empire for which it fought."

F.E.G.S.

THE NEW ZEALAND TUNNELLING COMPANY, 1915–1919. Edited by J. C. NEILL, Associate Otago School of Mining. (Late Lieut. N.Z.T. Company). Whitcombe and Tombs, Ltd., Auckland, N.Z. 9/6.

Reviewed by Major-General R. N. HARVEY, C.B., C.M.G., D.S.O., A.D.C.

THE book opens with the letter written to the O.C. of the Unit, by Lieut.-General Sir Alexander Godley, K.C.B.,K.C.M.G., on their departure from France, a generous appreciation of their work. It was always a matter of regret that the New Zealand Tunnelling Company could not be allocated to the New Zealand Expeditionary Force, but the exigencies of mining work on the front forbade this arrangement being made.

The birth of the Company, its training, its voyage home, round The Horn, narrowly escaping the German Raider *Möwe*, are well sketched.

It is of interest to R.E. officers to know that the original Commanding Officer, Major (now Lieut.-Colonel) J. E. Duigan, D.S.O., *p.s.c.*, was an officer of the Royal New Zealand Engineers before that Corps was disbanded and amalgamated with the Royal New Zealand Artillery to form a Coast Defence Electric Light Section, in 1909. As a New Zealand Engineer officer, Major Duigan came to England about 1907, and went through a course of E.L. at Gosport, and then through a course at S.M.E. His pleasant recollections of his experiences at the schools ensured a welcome at his Mess for all R.E. officers.

The Company arrived in France shortly after we had taken over the line between Arras and Loos from the French in 1916, and was a very welcome addition to the Tunnelling Force. The section of the line they took over just north of Arras was almost without defensive mines, the French system being to sink listening chambers just below the front parapet, and when the Germans were heard working too close, the line was retired.

Lieut. Neill describes how the British methods were introduced and perfected with complete protection to the infantry above. This was not accomplished without great risk and much hard work, and the New Zealand Tunneller soon showed that he could beat the Boche both in footage and cunning. In the early chapters claims are made on behalf of the mining methods of the Unit, in respect of timbering, size of gallery, and inclined shafts as against vertical shafts. As Inspector of Mines I had ample opportunity to study every variety of method and I found

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that every Company of the 35 under me had its own peculiarities as regards these items. It is quite impossible to convince a miner that any system is better than the one he employs, unless you can point to loss of footage, increased risk of damage by the enemy, or difficulty of getting rid of spoil.

This unit could drive its big galleries (6 ft. × 3 ft.), use timber from any source at all, and make inclined galleries without losing mining effect, and, therefore, their methods were found to be good, but not necessarily better than those of other units in other sections.

The footage of this unit was always good. I remember a case of one serjeant doing 21 ft. of 6 ft. × 3 ft. gallery; he was working at the face continuously for 17 hours in very broken chalk.

The construction of the Arras Tunnels is now history. It is very well told, and was a piece of work which redounded to the credit of the Unit, and in connection with this work was the construction of the Russian Saps leading from the Tunnels out into " No Man's Land," hardly less important and much more dangerous.

After the battle of Arras the Company had a variety of work, road-making, dug-outs, machine-gun emplacements. The destruction of damaged shells was also entrusted to this unit. 13,000 18-pounder and 4·5 in. shells were packed into a disused mine gallery and detonated with 45 detonators in series on each of two electric circuits. The detonation was completely successful. On another occasion, the remnants of the dump which exploded at Wanketin, some 60,000 shells, were similarly treated.

In the first battle of Cambrai, the company was used for bridging, which was all well done, and in the winter, 1917–18, they formed a Rugby football team which was never defeated and won the championship of the region and the 4th Division Cup and medals.

The German offensive, March, 1918, found the Tunnellers still in the Arras sector, where they were employed in saving the situation, digging and making reserve lines. Later on in the general advance they assumed general engineering duties.

In this capacity they constructed in the VI. Corps Area, bridges at Havrincourt, Noyelles, Solesmes and Maubeuge, under the C.E. VI. Corps, as well as many others under the C.E. XVII. Corps. The Hopkins Bridge over the Canal du Nord at Havrincourt, was a remarkable piece of work, and carried out with complete success by Capt. J. D. Holmes, D.S.O. It is true that the designer visited the bridge just as all preparations for launching had been made and foretold that a period of four hours would be required. He unfortunately was unable to stay to see the launch actually carried out, and where his prophecy failed. As a matter of fact the failure of the rollers was a difficulty which could only have been got over by an engineer of considerable experience, and but for the resourceful inspiration of Capt. Holmes, the bridge would never have been launched. As it was, when it was safely launched and the tackles removed, it was found that one steel rope had been flattened by the strain and the bolt of one of the main shackles had been bent double. From this it can be understood that failure was very narrowly averted.

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I have a vivid recollection of watching Capt. Holmes and a trusty party of 12 men making fast the off-shore end of the bridge, half way across a gap 93 ft. deep, in failing light and blinding rain. The launch was completed next day.

The leading principle of this Company was that no difficulty or unusual circumstance in connection with bridge building, or any other work, was allowed to interfere with successful achievement. There are two misprints which should be corrected: Major-General Sir William Liddell's name is spelt Liddle and the C.E. of the VIth Corps is twice named as C.R.E. IV. Corps.

Lieut. Neill must be congratulated on the production of this volume of 156 pages in which the birth, life, work and compliments thereon are so admirably and succinctly recorded. His story is told simply, accurately, with no exaggeration, but rather understating the importance of the works on which the Company was employed. The illustrations are excellent.

The spirit of the book is like the work of this most efficient unit, it goes with a bang from start to finish.

RAILROAD CONSTRUCTION.

By WALTER LORING WEBB. 7th edition. 1922. Chapman & Hall. 30/-.

Reviewed by Major and Bt. Lieut.-Colonel W. G. TYRRELL, D.S.O., R.E.

THE first edition of this work saw the light of day in the year 1900, since when seventeen thousand copies have been issued, which speaks well of its reception by the engineering profession, and the book will probably be found in constant use in all countries where English-speaking engineers construct and maintain railways.

Many of the methods advocated and the materials described are more or less peculiar to practice in the United States, while the section on rolling stock is entirely so.

The work as a whole suffers from two defects:—(1) In common with nearly every work on the subject, the various sections are not presented to the student (for whom it is, apparently, primarily intended) in the order in which he will have to deal with them in practical work later on.

For instance, skill in the conduct of railway reconnaissance and preliminary survey can only be acquired after years of experience and hard work. Yet these matters are presented to the budding engineer, at the very beginning of the work, together with illustrations of examples of problems of such difficulty that they would not normally be tackled by engineers of under 20 years' experience. Also nothing is said of the difficulties and requirements of maintenance, without a sound knowledge of which, competence in construction cannot be expected. (2) In a book of some six hundred pages, which attempts to cover the vast amount of ground covered by the whole of railway construction, the subject can only be dealt with generally.

If detail be introduced, each of the twenty-five chapters will rapidly swell into a fair volume in itself. It is a pity, therefore, to see

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numerous items dealt with most minutely, as they are apt, for this reason, to gain undue prominence in the beginner's eyes, which will be correspondingly blinded to items of equal importance which are treated generally.

As an adjunct to a course of instruction this book is to be strongly recommended, but it should not be used as a self-instructor. The experienced engineer will appreciate and welcome this new edition.

The chapters on alignment, earthwork and trestles are particularly useful, and the section on railway economics as affecting location (Chapters XIX to XXIII) is a thoroughly sound short treatise.

The tables and formulæ, at the end of the book, are primarily intended for outdoor use, and should therefore be published separately.

BALISTIQUE INTERIEURE.

By LE GÉNÉRAL GOSSOT AND M. LIOUVILLE. (J. B. Baillière et fils. Price 40 fr.; cloth, 50 fr.)

Reviewed by Lieut.-Col. J. M. WADE (late R.E.)

IN this treatise formulæ for "Interior Ballistics" are derived by mathematical analysis.

"Interior Ballistics" comprises the relations between pressure, weight of charge, duration of combustion, velocity of the gas for various data, *i.e.*, calibre, length of bore, etc., up to the instant the projectile leaves the gun. Ballistics being dependent upon experiment, a portion of the book is devoted to an exposition of the methods employed for practically determining the pressure developed by propellants, and other details, and from the results of the experiments numerical values are assigned to the constants appearing in the formulæ.

The analysis is of a very high order and, though the subject is rather outside the interest of most R.E. officers, it merits the most careful study by the scientific artillerist.

I gather that the work will be followed by a sequel on "Exterior Ballistics."

THEORY OF WAVE TRANSMISSION.

Reviewed by Lieut.-Col. J. M. WADE, late R.E.

By GEORGE CONSTANTINESCO. (Walter Haddon. Price, 10s. 6d.)

THE methods of transmitting energy known and practised by engineers can broadly be divided into two classes: (*a*) Mechanical, including hydraulic, pneumatic and wire-rope methods; (*b*) Electrical.

All methods of transmitting energy through a liquid, as heretofore applied, depend on the continuous transmission of pressure through it, so that the pressure applied at one end can be utilized at the other; in such forms of transmission the liquid merely acts as a connecting rod.

Suppose that we have a very long helical spring AB enclosed in a pipe, and that the end A is given a simple harmonic motion by means of a rotating crank; at each shock the spring near A

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will be compressed but will expand subsequently, the effect of the impulse, however, will travel along the spring with definite velocity. The inertia of the coils of the spring remote from A provides the resistance required for the compression of the spring near A; on cessation of the impulse expansion takes place in both directions, so that a wave of pressure and displacement will move along the spring. Under certain conditions the motion of the end A can be reproduced at B, and this motion of the end B can be used to rotate a shaft.

In this method of transmitting energy it is to be observed that the elasticity of the medium (a spring in the example quoted) is directly utilized.

Now liquids, though at one time thought to be, are not actually incompressible; they possess a definite measure of elasticity under compression, and when enclosed in long pipes their elasticity under certain conditions can be utilized for the transfer of energy by the transmission of impulses, and the principles involved in such transfer do not differ materially from those briefly outlined in the case of a spring. In the treatise of wave transmission by Mr. Constantinesco the foregoing principle is made the basis of a mathematical discussion concerning the transmission of energy through liquids enclosed in long pipes by impulses. The subject is fully, clearly and very ably discussed, and though, perhaps, outside the field of interest of most R.E. officers, is well worth study by those engineers who specialize in power transmission.

REPORT ON THE PALK MANUSCRIPTS (HISTORICAL MANUSCRIPTS COMMISSION.)

(H.M. Stationery Office. Price, 12s. 6d.)

THIS Report on some 470 letters addressed to Sir Robert Palk from the time when he relinquished the governorship of Madras, in 1767, down to the end of 1786, has been prepared at the suggestion and with the co-operation of the India Office by Colonel H. D. Love (late R.E.), and must have been a labour of more than ordinary interest to one who has spent many years of his life in the Madras Presidency. Palk himself had an exceptional career. He went out to India first in 1747 as a Naval Chaplain, and after occasional duty on shore he obtained the remunerative appointment of Paymaster and Commissary in the Field to the Madras Government, and eventually became Governor of the Presidency for three-and-a-half years. Fortunes were made rapidly in those days in India, and Palk lived for his last thirty years in England in wealth and comfort and became Member of Parliament and a Baronet. His correspondents were of all classes, British and Native, from Warren Hastings and Admiral Sir Edward Hughes downwards. There is one letter from James Rennell in which he mentions his "General Survey of Bengall, Bahar, our part of Oriza and the Provinces of Allahabad and Awd," but it is tantalizing to find that the arrival of Major-General Sir Archibald Campbell to take up the Governorship of Madras occurred at the very end of the period of the letters. The editing has been

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done very thoroughly ; there are copious personal notes and a complete index. As an example of these old-world documents one may quote from the letter of an Agent (not Cox) : " So, as it can't be better, why you must e'en be content 'tis well as it is—

Si fortuna vestra te tormento,
Let sperato te contento."

F.E.G.S.

THE MYSTERY OF MR. W. H.

By Colonel B. R. WARD, C.M.G. (Cecil Palmer. 7s. 6d. *Illustrated.*)
Reviewed by Lieut.-Colonel M. W. DOUGLAS, C.S.I., C.I.E.

THE tercentenary of the publication of the First Folio of Shakespeare's plays will no doubt be commemorated by literary appreciation and criticism ; and two members of the Corps of Royal Engineers are already in the field, Lord Sydenham with an article in the January number of the *Nineteenth Century*, and Colonel B. R. Ward with this work. By the courtesy of the Editor, the first two chapters have been republished from the *National Review*.

Colonel Ward enters the lists of the Shakespearean Controversy convinced that Shakspere of Stratford was not the author of the Shakespearean plays and poems. In " Mr. W. H." he describes a series of Shakespearean discoveries, principally connected with the *Sonnets* and supported by inferences strengthening the hypothesis put forward by Mr. J. T. Looney in 1920 (*Shakespeare Identified*) that Edward de Vere, 17th Earl of Oxford, and Shakspeare are identical personalities. His conversion came through reading Mr. Looney's book, and that by Prof. Abel Lefranc (*Sous le masque de William Shakespeare*, 1919) which proved to him that Lord Derby, the son-in-law of de Vere, was also concerned. We read that " our earle of Darby is busye in penning commedyes for the commoun players." As de Vere had lived in Hackney for the latter years of his life, Colonel Ward made a pilgrimage to Hackney. He began his quest with the *Sonnets* published on the 20th May, 1609 as *Shake-speare's Sonnets* and prefaced by the following dedication :—

> " TO THE ONLIE BEGETTER OF THESE INSUING SONNETS MR. W. H. ALL HAPPINESSE AND THAT ETERNITIE PROMISED BY OUR EVER-LIVING POET WISHETH THE WELL-WISHING ADVENTURER IN SETTING FORTH." T.T.

It is generally admitted that the initials " T.T." stand for Thomas Thorpe the publisher, and those of " W.H." for William Hall, a stationer and procurer or " begetter " of manuscripts, who had " procured " and published in 1606 *A Foure-fold Meditation* by Robert Southwell. The coincident collocation of letters " Mr. W. H. all " strengthens this view. Mrs. Stopes had suggested that " the dedication reads like a wedding wish." The interest centres around King's Place, now Brooke House, Hackney, where Lord Vaux had lived and had sheltered Southwell, a Jesuit suspect. Lord Vaux died in 1595 and his house had been occupied thereafter by the Earl and Countess of Oxford. The Earl died there in 1604, and, in 1609, the Countess of

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Oxford had sold King's Place. There was no theory extant to support the procuring of the *Sonnets* by " W. H." from either Shakspere or Bacon. Whence, therefore, had William Hall procured them, and the *Foure-fold Meditation*? Was he married in Hackney and a Hackney man?

Following this train of thought, Colonel Ward searched the parish registers, where he found that "William Hall and Marjorie Gryffyn were joyned in matrymonye on the 4th August, 1608" or nine months before the publication of the *Sonnets*. This relevant fact led to the inferences:—That William Hall of the dedication was a Hackney man and had been married there; and that he had procured both MSS. from King's Place, the *Foure-fold Meditation* in 1606, the *Sonnets* in 1609. Further, that the words " our Ever-living Poet " referred to an author not living at the time of publication, a point fully discussed in an *Appendix*. This latter inference granted, the conclusion remains, supported by other links, that de Vere was the author of the *Sonnets*; as other claimants, Shakspere and Bacon, were then alive. Again, *Sonnet* 125 begins:—

> " Were't aught to me I bore the canopy,
> With my extern the outward honouring,"

It is believed that this sonnet was written shortly after the death of Queen Elizabeth; and Oxford, as Lord Great Chamberlain, would have been among the six Earls who " bore the canopy " at the funeral.

It is reasonable to accept that William Hall of the dedication and William Hall of Hackney are identical; the further inferences will depend on our individual sense of probability. During the first 38 years of his life, de Vere was royal ward, courtier, poet, and favourite of Queen Elizabeth. He possessed a company of players and was regarded as one of the best writers of comedy of the time. Then came his trial and the crisis which impelled him to deplore " the loss of his good name " and to withdraw from the Court and Public. From 1588 until his death in 1604 he lived in retirement, generally in the neighbourhood of Hackney. It is shown that this period coincides approximately with the periods of Shakespearean publication and the growth of prosperity of the Stratford man. The publication of the First Folio in 1623 is also in harmony with the de Vere theory; and was possibly undertaken by the Earl of Derby as literary executor for his father-in-law on behalf of Oxford's three daughters, " the Grand Possessors " of the MSS. Whereas also neither Shakspere nor his heirs and executors were in any way associated with the publication of the First Folio, most of the names mentioned were of persons who, in some way, had been connected with de Vere; and the Earl of Montgomery, one of " The Incomparable Paire of Brethren," to whom the Folio was dedicated, was his son-in-law.

Mr. Andrew Lang, in his vindication of the Stratford man, *Shakespeare, Bacon and the Great Unknown*, wrote in reply to Sir George Greenwood, " What Mr. Greenwood's great unknown was doing at this period (1599 to 1605) neither does he know nor do I know but he only. He no doubt had abundance of leisure." It is unlikely that de Vere, with his

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strong literary bent, was idle during his seclusion. Is it possible that Colonel Ward has provided the answer? He has doubtless solved "the mystery of Mr. W. H." but leaves the reader to solve the greater "mystery of Mr. W.S.," or Shakspere of Stratford.

We read (*Puttenham*, 1589) that in her Majesty's time . . . "are sprung up courtly makers (poets)" . . . who are "loath to be known of their skill . . ." and suffered their efforts to be published anonymously . . . "of which number is first that noble gentleman Edward Earle of Oxforde." The custom of collective writing by collaboration is described by Mr. Lang, and literary piracy was rampant. The following thoughts are suggested. That de Vere wrote the *Sonnets*, *Hamlet* and certain plays, some in collaboration possibly with Bacon, Derby and others. That, owing to the discredit attached to play writing, and, in de Vere's case, to the shadow which persistently falls across his life, the authorship was suppressed. That Shakspere of Stratford, the jovial actor, manager or broker, and even writer of some skill, was paid to produce the plays and even take credit as Shake-speare the author. Thus did he become rapidly prosperous and retire to Stratford in middle age. Here again our reflections will, however, depend on the personal equation of our belief. The book is an interesting record of research, as well as the manifesto of "The Shakespeare Fellowship" which has been organized by Colonel Ward, with Sir George Greenwood as President; and should be studied by all who are of an open mind on the question of Shakespearean authorship.

THE DRAYSON PROBLEM.

HIS IMPORTANT ASTRONOMICAL DISCOVERY. *By* ALFRED H. BARLEY. Exeter. William Pollard & Co., Ltd., Bampfylde Street. 1922. Price, 1s. 6d.

Reviewed by Colonel B. R. WARD, C.M.G. (late R.E.).

APPENDIX No. XII of Guggisberg's popular history, *The Shop*, informs us that Captain A. W. Drayson, R.A., was on the Military Topography Staff as an Instructor from 1858 to 1867, and as Professor of the same subject from 1867 to 1873.

It was during the period of his instructorship that an incident occurred which led to a discovery so fundamental and far-reaching that it determined the whole course of his subsequent life, and was the starting point of a voluminous literature which Mr. Barley summarizes in the pamphlet under review. The incident which was destined to have such far-reaching results occurred in one of the Shop class-rooms after a lecture on Astronomy by Captain Drayson. He had been discussing the problem of the Precession of the Equinoxes and the Obliquity of the Ecliptic—problems whose very titles are enough to terrify, but which are far less alarming when considered geometrically rather than analytically—and the explanation he had given of Precession was the usual one which has been given ever since the time of Newton, namely, that the pole of the heavens describes a circle round the pole of the ecliptic. At the close of the lecture one of the cadets enquired if the distance between the pole of the heavens and the pole of the

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ecliptic had always been the same. "No," was the reply; "it was formerly somewhat greater, and it is subjected to an annual diminution of about half a second, which is termed the 'Decrease in the Obliquity of the Ecliptic.'"

"Did you not say, just now," pursued the enquirer, "that the precession of the equinoxes was caused by the pole of the heavens moving in a circle round the pole of the ecliptic?" "So it is." "Then what is the centre of that circle?" "The centre? I told you, the pole of the ecliptic." "But you have just told us that the pole of the heavens is decreasing its distance from the pole of the ecliptic. How, then, can this be the centre of the circle which is being described by the pole of the heavens?"

The only reasonable answer to this question is that "someone had blundered," and that some point, other than the pole of the ecliptic, must be the point round which the pole of the heavens is travelling. Eventually Drayson found that the central point in question is not the pole of the ecliptic, but a point six degrees from it.

To understand this in a general way is by no means difficult, if it is considered as a problem in solid geometry, but to prove it by analytical methods is by no means so simple. Mr. Barley has, however, not shrunk from the task, although the calculations occupied seven years instead of the seven days he first allowed himself for the job.

How geological evidence of the last Ice Age confirms the truth of Drayson's discovery, and how disbelief in Drayson's new centre is following precisely the history of disbelief in the new centre discovered by Copernicus in 1544, is set out in this very interesting pamphlet.

It is curious to notice that Shakespeare, sixty years after the Copernican discovery—in the character of Hamlet, writing to Ophelia—thus expresses his belief in the old Ptolemaic system:—

"Doubt thou the stars are fire;
Doubt that the sun doth move;
Doubt truth to be a liar,
But never doubt I love."

Francis Bacon, great scientist that he was, similarly never faltered in his condemnation of the Copernican theory. The older he got the more obstinately did he refuse to entertain the idea that the sun was the centre round which the Earth and the other planets revolved; and as he died in 1626, eighty-two years after Copernicus had made his famous discovery, it is hardly surprising that in this year of grace, 1923, less than seventy years after Drayson's discovery, no astronomer or mathematician of any eminence has yet ventured to accept the new centre.

POINTS OF VIEW.

By The Right Honourable The Earl of Birkenhead. (Hodder & Stoughton). Price, £2 2s. 0d.

This book contains an able defence of Lord Kitchener, by one who claims his friendship and even intimacy, against the grave criticisms and inaccuracies expressed by Lord Esher in his book *The Tragedy of Lord Kitchener*.

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" Someone—I cannot remember who—a long time ago dismissed a German biography, of which Chatham was the victim, as the effort of an owl blinking at an eagle. Lord Esher is not by any means an owl. But his monograph leaves upon the mind the painful expression that, in just perspective, he has failed to understand and value an indomitable Englishman, who was his friend, and who died for England."

THE GOLDEN HAMMER.

By A. W. MARSHALL. (Percival Marshall & Co.) Price 3s. 6d.

A little book of " Engineering Stories," originally published in *The Model Engineer* or in *Junior Mechanics*, intended for juniors and evidently written as an introduction to the practical " Model Engineer " series of handbooks.

F.E.G.S.

MAGAZINES.

REVUE MILITAIRE GÉNÉRALE.

(*August–October*, 1922.) *Could We Continue to Fight ?*—In the August and September numbers appears a very interesting article by M. G. Marul, which is the translation of a German article by Adolf Köster. An editorial note mentions that this will be of great historical importance, since Herr Köster is well qualified to write of Germany's condition in the autumn of 1918, when he was Home Minister of the Reich.

Herr Köster's object is to controvert what he calls the " Ludendorff Legend," that the German Army was traitorously stabbed in the back in 1918 by the moral collapse of the civil population. The lack of men and materials for the armies, the latter due to the blockade, the unfavourable strategic position of the armies, and economic collapse, were the real reasons which made it impossible for Germany to continue the struggle.

The Revision of the Regulations.—The article by " Lucius " is continued in the August issue, dealing with the increasing boldness and persistence of the Allied attacks, and Ludendorff's renewed instructions on, and modifications of, his defensive measures. The lessons to be deduced from the 1918 operations are enunciated.

In the October number begins a summary of the main lessons of the war in relation to post-war doctrines and the new regulations. First, open warfare demonstrates : (*a*) the preponderating importance of fire, and, to counteract its effects, the general use of field defences ; full preparation before, and method in, the conduct of each operation are essential, the contradictory demands of method and rapidity must be reconciled as may be best ; the adoption of less vulnerable formations, infantry extended to five paces as the probable limit, and well supplied with fire-arms of every nature ; (*b*) The necessity for thorough intercommunication between the various arms, which must all act for the benefit of the principal arm, the infantry ; (*c*) A large measure of initiative must be delegated to the actual combatants ; (*d*) The encounter

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battle must still be expected on a greater or lesser scale at every stage of the operations. This leads to consideration of (1) reconnaissance and gaining touch with the enemy. Aeroplanes can give general information, cavalry can, perhaps, locate the actual line of fire and its flanks, but a body of infantry alone, with artillery support, can ascertain the strength of that line, and if this advanced guard or first line of battle is not to be cut up by superior forces the main body must be sufficiently close to support it, rally it after a check or accept battle in case of need.

The Shadow of a God.—In this article, in the August number, Captain de Gaulle points out how slowly military tradition dies, and the way in which the German general staff and Army Commanders in 1914 essayed to imitate the methods of the first von Moltke and his Army Commanders in 1866 and 1870. The parallel drawn is interesting, but owing to the more rapid means of intercommunication now in use the advisability of following such methods is decidedly questionable at the present day. In 1914 the result in the case of von Kluck's Command was unfortunate.

Reflections of an Artillery Officer (September number).—An editorial note mentions that this article is an extract from a book by General Rouguerol, *Après la Victoire*, published by Berger-Levrault. It describes the difficulties and powerlessness of thinking artillery officers before the great war in their attempts properly to organize the higher artillery commands and co-ordinate the various artillery echelons in battle. The General Staff, obsessed by its conception of all wars as those of movement, considered that the proper place for the senior artillery officers was at the base in the capacity of supply officers, receiving their orders through a junior officer on the Staff. As a result, France entered on the war with few artillery officers of high rank trained and with suitable staffs, without heavy field artillery and with insufficient ammunition for her field batteries. The demoralizing effect on the infantry of the impossibility of effectively replying to the German heavy guns was disastrous, the make-shifts at first resorted to did little to improve matters, and it was not until after the first two years of the war that the artillery organization and equipment could be placed upon a satisfactory footing.

(*November*, 1922.) *The First Army Corps at the Battle of the Marne, 6th to 13th September*, 1914.—A narrative account by General Deligny of the operations of his Corps. Without entering into great detail, the information and orders received and the action taken on them are shortly related with each day's events and progress.

The Revision of the Regulations.—A continuation of the article by "Lucius." After some further remarks on advanced guards, (2) the composition, employment and action of outposts are discussed. Secondly: The general lessons of position warfare, characterized by the long duration of the battles, are analysed. (*a*) The aims of open and position warfare are the same, but the procedure differs; the Army must therefore learn the tactics of both. (*b*) Since a defensive attitude is frequently imposed, the principles of defence should have a place in

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the regulations. (*c*) The consequences of the long duration of each battle and means for minimizing its inconveniences must be well understood, which leads to some discussion on the composition and employment of divisional and higher formations and their staffs. (*d*) Further remarks are made in regard to the antagonistic demands of method, and rapidity of execution; the conclusion arrived at is that the former must be practised until the position is reached, after which decentralization of command is necessary if the full fruits of the victory are to be reaped. (*e*) The rapid exhaustion of the infantry, and the parallel increase of material and mechanical means receives attention. (1) It is recommended that the fourth regiment be restored to the division; (2) the machine cannot replace the man, infantry is ultimately the supreme arbiter in the combat and, whatever saving of personnel may be possible in other arms, a reduction in the numbers of the infantry below a certain limit. must involve grave risk. (*f*) The complications introduced into the conduct of a battle due to recent mechanical inventions are touched on.

Transatlantic Air Communications.—A short article by Colonel Defrasse, speculating on the possibility of instituting a service of airships across the Atlantic, with more special reference to services from Rome to New York and Buenos Aires which have been proposed in Italy.

Les Semeurs de Haine, by André-Fribourg (Berger-Levrault).—A review of this book says that its object is to prove that wars between nations have always been the result of the systematic working of "sowers of hate." The author has been tracing in Germany the organization of the patriotic and political propaganda which are driving Europe light-heartedly into a new cataclysm. Posters, pamphlets, songs, the theatres, the cinema, countless leagues and associations, university, government, the press, all are *semeurs de haine*, preaching the invincibility of the German Army, the denial of German culpability, the injustice and indignity of the Versailles treaty, the denial of German war crimes and the outrage to civilization caused by the presence of black troops on the Rhine.

(*December*, 1922.) *What is the Future of the Red Army?* By General T. Rostovtzeff.—After describing the qualities and limitations of officers and rank and file, and the organization, or want of it, in the Soviet army, the writer indulges in some speculations as to its future. Owing to want of money the government cannot maintain an adequate regular army and pay officers and men a living wage. An army of militia would be cheapest, but there are two great objections to it, (1) that transport is too disorganized to admit of mobilization in a reasonable time, and (2) the Bolshevist distrust of the peasant. Probably a "governmental force" will be formed for internal defence (and incidentally to keep the Soviet in power), the equipment for which may be maintainable in view of the comparative paucity of its numbers. It was for this reason, and not on humanitarian grounds, that Chicherin at Genoa pleaded for a reduction of armaments and the signature of pacts of non-aggression with the states bordering Russia.

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The Revision of the Regulations.—The article by "Lucius" is continued. (*g*) Cavalry must be retained at all costs, and not converted into mounted infantry. In open warfare its use is as great as ever, and, even if it is seldom called upon in position warfare, nothing else can replace it. (*h*) The training of troops should not only develop the lessons of the last war, but should keep abreast of the times and include practice with newly-invented warlike processes, the true advantages of which are not always evident until they have been brought into actual use. (*i*) The lessons of position warfare are briefly summarized. (3) The present day conception of the offensive differs to some extent from pre-war notions. (*a*) The principle of superiority of force at the decisive point survives, but is modified by the necessity for prolonged effort, and for not exposing more than a minimum of troops at a time to the disastrous effects of modern fire-arms. It becomes more a matter of reserves of men and materials and superiority of fire. (*b*) Surprise must still be striven for by processes already described. (*c*) The problem of the development of the success was not satisfactorily solved during the war. It is fundamentally a matter of bringing up fresh reserves at the critical moment, which can only be satisfactorily accomplished by keeping infantry in cantonments 15 km. or so to the rear, and rushing them up by motor transport, while mounted troops can follow those already engaged. (*d*) Moral superiority is more than ever important and must be fostered by every possible means.

Nieuport, 1914–1918.—An extract from a forthcoming book of the same title, in which Commandant Robert Thys, of the Belgian Engineers, describes the flooding of the country in front of the Allied line in Belgium, the maintenance of the sluices, etc. The inundations secured the stability of that portion of the front during the whole course of the war, and, curiously enough, the possibility of making them was entirely overlooked by the Germans, in spite of historical records of their use in former campaigns. The book is said to be richly and profusely illustrated.

Chronicles of Foreign Armies.—The armies of the Baltic States are dealt with this month. A.R.R.

BULLETIN BELGE DES SCIENCES MILITAIRES, 1922.

(*Nos. 6 to 12 inclusive.*)

A series of articles dealing with the operations of the Belgian Army during the Great War, 1914-1918, has been appearing in the successive numbers of the *Bulletin* published during 1922. The authorship of the articles is anonymous; however, there is every evidence that the narrative is based on official records. The articles are illustrated by maps and plans upon which the defence works and positions of the troops are, in some cases, marked; the doings of the Belgian Army are given in considerable detail and will repay a careful study. The numbers of the *Bulletin* under notice deal in part with the defence of the southern sectors of the Fortress of Antwerp, which, as is well known, it was expected would play a very important rôle in any war in which

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Belgium might be engaged; the idea being that, if the worst came to the worst, the Belgian Army could take refuge in the Fortress and withstand a prolonged siege within the limits of its defence works.

The very elaborate and complete preparations which the Great General Staff of the Kaiser's Army had made to batter down the permanent, as well as the field, defences standing on the line of advance of the German Armies into France (as also on their flank), and the intention rapidly to push through at any cost to their main objective, to a great extent upset the calculations of the Belgian Higher Command. It soon became evident that the Belgian Army would not be able to hold out in Antwerp for more than a few days. It has, in consequence, been argued that, in view of the great developments which have taken place in artillery, and the facility with which the heaviest armament can now be brought into the field, where railways exist, it is no longer worth while to spend large sums of money on permanent fortifications. The narrative relating to the defence of Antwerp contained in the numbers of the *Bulletin* under notice conclusively proves that permanent defences, even when antiquated, armed with pieces of inferior weight to those of the attackers and supported by an insufficient field army, cannot be put out of action as easily as is sometimes imagined. In the narrative, incident after incident is given showing that, although the antiquated permanent works forming the defences of the famous *place forte* were bombarded by guns and howitzers, ranging from 4 in. to 16·5 in. in calibre, and were seriously damaged by their fire, nevertheless, under resolute Commanders directing brave troops, the forts did hold up the Germans and prevented them from immediately breaking through the Belgian defensive lines into the heart of the city. The German troops sent forward to the assault on several occasions retired without reaching their objectives, and reported that the Belgian forts were not yet "sturmreif." Thus valuable time was gained by the defenders, very short of expectations though it may have been. It is not difficult to conjecture how very different the situation might have been, had the permanent defence works of Antwerp been more up-to-date and armed with weapons of a calibre equal to that of the attackers, and if, at the same time, an adequate field army had been available to deal with the invaders.

Some general lessons of value are to be learnt also from the narrative. Reading between the lines, there would seem to have been a failure on the part of the Belgian Staff to make the fullest use of the engineer arm and, further, to co-ordinate the work of the engineers in a manner best suited to meet the general needs of the situation. The arrangements made to enable the troops to pass from the south to the north bank of the Nèthe, and *vice versa*, do not appear to have been adequate: the requirements in this locality were not sufficiently carefully planned out in peace time, and, in consequence, there was a shortage of suitable bridging material on the spot when it was most wanted. The Engineers worked hard to improve access to the river and to construct rafts, but were handicapped owing to this shortage of material. The river is tidal, and, with the arrangements made, traffic across the stream at the temporary crossings had, during parts of the day, to be suspended. Again, in other cases, the Engineers blew up permanent

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bridges prematurely and hampered the movement of the Belgian troops. Now, experience teaches that no amount of hard work on the part of regimental officers and the troops will ever get over the results following upon bad staff work. In modern war, technical considerations are so very important, and yet they are so often overlooked that the question arises whether the time has not arrived generally to recast existing staff organizations and methods with a view to ensuring that in the planning of all operations due regard shall be paid to the highly technical aspects of all military problems so that the technical troops may be used and utilized to the fullest extent possible.

Nos. 4 and 10 of the *Bulletin* contain, in outline, an account, which is illustrated by sketch maps, of the operations in the Italian theatre during the Great War. In the former number, the narrative is brought down to and includes the story of the Battle of Caporetto, while in the latter number is given a brief description of the Battle of Piave. A useful summary of the German Field Service Regulations, issued on September 1st, 1921, which treat with the handling of the combined arms in battle, is contained in Nos. 4 to 12 (inclusive) of the *Bulletin*. A good deal of space is devoted to the Air Force, Cavalry and Artillery, but, as is often the case in publications of this kind, the functions of the engineer arm are to a great extent slurred over. This is unfortunate, as it is more than ever essential that the various arms of the service should be fully informed in regulations of this kind what are the functions and limitations of each and every arm. Unless it is fully set out and made clear what part each arm can, and must, play, whether in attack or defence, there is a danger that the fullest co-operation may not be secured in the field between the several component parts of formations, be they small or large. A series of articles, under the title, " What Have We to Fear from Germany ? " appear in Nos. 7 to 9 of the *Bulletin*, wherein the question is discussed as to whether the manufacture by Germany of poison-gas can be prevented or limited. Germany still has, it is alleged, a monopoly in chemical manufactures, and the most logical solution of this difficult problem, it is suggested, consists in the destruction of the German monopoly and in an equal distribution among the various nations of Europe of the enterprises connected with the manufacture of chemicals. The suggested solution is not a practical one, unfortunately ; accordingly, it behoves each nation that it should take a far-sighted view of the question, so that in the days of trial to come a surprise may not be sprung upon it as was the case in the Great War. The problem of *liaison* in the field receives attention in Nos. 7 and 8 of the *Bulletin* : the articles are based on the Belgian instructions on this subject issued on August 8th, 1918. The various means employed or available for transmitting verbal and written communications from point to point are summarized. It is pointed out that, although the organization of *liaison* is a matter pertaining to the domain of the General Staff, on the other hand, the physical transmission of messages and matters affecting the equipment required for the purpose, lies wholly in the technical domain and must be left altogether in the hands of the special troops to whom are entrusted the executive duties relating to the communication services.

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The text of certain important communications addressed by von Hindenburg and by von Ludendorff to the German Chancellor and to the German War Minister during the Great War are republished under the title, " Battle Wears Out an Army. An Army Wears Out a Nation." These communications disclose, to some extent, the effect of the Great War on the resources of Germany, and indicate that modern war is as much a matter of destroying the economic structure and resources of a State as of killing and wounding its soldiers on the battlefield. In Nos. 11 and 12 of the *Bulletin* some account is given, with illustrations and sketch maps, of the Inundations carried out on the Belgian front during the Great War. Many interesting problems had to be dealt with. As soon as the decision was taken to inundate the region southward of Dixmude, a special branch of the Engineer Staff was created for the purpose of studying the complex questions involved. Later, in the spring of 1915, it was recognized that troops with a particular kind of experience would be required to look after the dikes and the special plant in use in the inundated region. Consequently, a Company of *Sapeurs-mariniers* was raised and took over the duties in connection with the maintenance, etc., of the hydraulic works in this region. Details relating to the inundations alongside the railway are given in the narrative, and that also east of the Yser between Dixmude and Fort Knocke. Some of the problems connected with the control of the waters in the Wateringue of Furnes and the management of the waters in the several sections of the inundated front are discussed. The measures taken to reclaim the inundated land for the purposes of the offensives from the British front in 1917 and in 1918 are touched upon.

Commandant Jacquet contributes an account, illustrated with sketch maps showing the disposition of the opposing troops, of the German offensive in Picardy (March 21st–April 4th, 1918). The reasons which prompted the German Higher Command to select the particular part of the line actually chosen for the delivery of the blow against the Entente front are gone into, and an account is given of the preparations made by the Germans, a large amount of which fell on the engineer arm. Apart from the fact that von Ludendorff aimed at the point of junction of the British and French Armies, in order to separate and get in between them, another of the main reasons why the blow was struck against the fronts of the British Third and First Armies lies in the fact that the Germans calculated that this part of the British front, which was of recent occupation, would not be as strongly fortified as the more northerly parts of the British front. Further, the Germans seem to have been fully aware of the fact that the trenches on the section of the line chosen for their offensive were lightly held.

The question as to whether Colonel Hentsch was actually responsible for the retreat of the German First and Second Armies from the Marne is closely examined in an article by Lieut. Fraeys published in No. 11 of the *Bulletin*. The evidence which is available (and some of it that is contemporaneous with the events under discussion is fortunately documentary) distinctly clears Colonel Hentsch from the imputation of having hastily interfered in the situation which he found existing on arrival at the battle-front, and of having in this way brought about

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disaster to the German arms on the Marne. On the contrary, the evidence tends to show that the German Higher Leadership was not equal to the demands made on it on this occasion.

The remaining articles in the numbers of the *Bulletin* deal with aviation, psychology, musketry, infantry and artillery tactics, etc., but are not of the same importance as those to which attention is called above.

W.A.J.O'M.

REVUE MILITAIRE SUISSE, 1922

(*Nos. 4 to 12 inclusive.*)

Attention is called, in No. 4 of the *Revue*, to the new edition of the *Règlement des pontonniers* to which the Swiss War Office gave its approval on December 21st, 1921; the contents of the volume differ materially from those of the edition of 1913. A summary, with illustrations, of the contents of the 1921 edition is contained in the original article. It is pointed out that the bridging material in the hands of the Swiss engineers was designed in the days prior to the introduction of heavy mobile artillery and of mechanical transport. The Regulations of 1913 provided for what was known as a " heavy bridge," suitable for carrying vehicles up to a maximum weight of 6,000 kg. (approx. 6 tons). The introduction of mechanically-driven vehicles necessitated provision being made for floating field bridges capable of carrying wagons weighing, when loaded, up to 10 tons or so. In the 1921 Regulations provision is made for a new " heavy bridge " which will carry vehicles having a maximum weight of 9,500 kg. (approx. 9½ tons). The Swiss engineers have solved the problem put up to them in such a way that the existing bridging equipment and stores can, with very slight modifications, still be utilized in the construction of the new heavy type of bridge, details relating to which are given in the original article. Before complete effect can be given to the 1921 Regulations, it will be necessary for the Federal Chamber to vote funds for the conversion of the bridging equipment and stores in the hands of the Swiss Army. Although the *Règlement des pontonniers* deals mainly with engineering details, the final Chapter is devoted to the discussion of the tactical problems connected with the passage of rivers in face of an enemy. Colonel Lecomte, the author of the original article, takes exception to the inclusion of a Chapter dealing with tactical problems in a volume dealing with a technical subject of a specialized kind. He argues that a volume of this kind is not likely to be consulted by the general body of Swiss officers; moreover, as the passage of a river in face of an enemy is an operation affecting the employment of all arms, he rightly points out that instructions on the subject should be issued not by a specialized arm of the service but by the General Staff. However, nothing in the nature of a Field Service Manual appears to have been issued in Switzerland; it may be the engineers have merely taken the initiative with a view to having the gap filled, and have probably consulted the proper authorities in order to make sure that the doctrines preached in their little volume do not offend tactical canons of the General Staff. Commandant Begou deals in Nos. 5 and 6 of the *Revue* with the tactical problem of the

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attack of a division: a trench warfare scheme is worked out on sketch maps, the rôle of the engineers being briefly touched upon. The *Training Manuals* published in recent times in France, Germany and Switzerland are brought under notice in Nos. 5 and 8 of the *Revue*. Colonel Poudret contributes notices relating to Colonel Grouard's *La conduite de la guerre jusqu'à la bataille de la Marne* and M. G. Hanotaux's *La bataille de la Marne* in Nos. 6 and 12 respectively. Colonel Grouard has taken up his pen in order to criticize what he deems to be the mistakes made during the operations with which he deals. He is impartial to the extent that he is as ready to point out what he considers to be the mistakes made by the French Higher Command, as well as those made by the German Higher Command and the British Commander-in-Chief. M. Hanotaux, on the other hand, has undertaken the task of defending Marshal Joffre and his Staff, and to explain the German movements in the light of the French strategy. Colonel Poudret presents a valuable analysis of the different points of view taken by the two authors on the principal matters in controversy in relation to the handling of the opposing forces during the critical days of the Great War. Colonel Feyler gives, in No. 9 of the *Revue*, an outline of the schemes worked out at the French G.H.Q., during the winters of 1915–1916, 1916–1917, and towards the end of 1917, in connection with a transfer by road of from 4 to 6 divisions to the Swiss frontier in the event of Germany launching an offensive *via* Switzerland against the right of the Entente front—the various hypotheses involved are clearly set out. A study of the problem in question led to the conclusion that, if the transport were held in readiness in anticipation of the moves, a covering force of the size mentioned could be conveyed to its destination within 11 days after the issue of the warning "Garde à vous"; otherwise, 16½ days would be required for the move. Outside Switzerland, the opinion held at the time was that, had Germany launched an offensive through Switzerland against the Entente right, it would have been unwise to rely on the resistance of the Swiss Army alone to keep back the Germans; this view is not comforting to the Swiss.

M. R. A. Jacques, an engineer, takes up the question of the Sixth Arm (Chemical Corps) in a series of articles contributed to Nos. 9, 10 and 11 of the *Revue*: he points out that the two outstanding features of the Great War were: (1) aviation, and (2) the wide use of chemicals. Problems connected with the limitation and control of armaments are discussed by him, and he points out that whereas a certain amount of supervision can relatively easily be exercised in peace time in relation to a force consisting of cavalry, artillery and infantry, on the other hand, difficulties of a serious kind are met with where it comes to the exercise of supervision in matters affecting the engineer arm. Again, in the case of the Fifth Arm (Aviation) and the Sixth Arm (Chemical Corps), although some small measure of control may be possible in peace time in the matter of regulating developments of a military kind in connection with aviation, it is altogether out of the question to attempt anything effective in relation to the chemical industry, which can, in peace time, be clandestinely built up as a powerful organization ready to be used for military purposes at a moment's notice. M. Jacques rightly

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lays it down that a nation which possesses a highly-developed chemical industry and an extensive commercial aviation service will at all times be an "armed nation," even should it most scrupulously respect the limitations of war material and the establishments of military personnel imposed upon it by international conventions. Brief notes are given concerning those chemicals which are largely used for agricultural and commercial purposes, and are, at the same time, of importance from a military point of view. In an article published in No. 11 of the *Revue*, Capt. Kunz examines the rôle played by the Fortress of Verdun in the Battle of the Marne. The narrative shows that at one time the instructions issued by the French G.H.Q., during the early phase of the Great War, were such that a literal compliance therewith would have involved a withdrawal of the French troops from the Fortress. Fortunately, the French Commander on the spot correctly appreciated the situation and managed to retain his hold on Verdun until the turn in the military tide on the banks of the Marne caused the Germans to desist in their attacks on the Fortress, which they had, by the way, approached with considerable caution, owing, no doubt, to some extent to their respect for the reputed strength of the French stronghold, but also because they do not seem to have learnt that the French troops in this region were numerically weak. The German V Army which was sent against Verdun was evidently hypnotized, and credited the defence works at Verdun to possess a greater resisting power than in fact was probably the case.

The remaining articles in the numbers of the *Revue* under notice deal, to a great extent, with subjects which are of more particular interest to Swiss readers.

W.A.J.O'M.

HEERESTECHNIK.

THE first number of the new magazine *Heerestechnik* has just appeared. It is a successor to the old *Technik und Wehrmacht* and is published by the "Offene Worte," Charlottenburg.

In his Introduction the editor states that the object of the magazine will be to give the professional soldier an insight into the technical and scientific processes of which he must avail himself in modern war. It would seem from this preface that such matters are regarded with dislike and indifference by the German professional soldier. Some of us will remember a famous saying in a captured German document which ran as follows:—"Alles was nach Wissenschaft schmeckt muss fern gehalten sein." One cannot but think, however, that the author's lament, though natural enough for a technical man to make, rather overstates the matter. A constant study of the art of war and perpetual training programmes are not conducive either to scientific reasoning or to technical polish, and the German officer is probably no exception to a general rule.

The magazine is to be divided into official and unofficial sections. It is presumed that the former section is kept for such articles as have official approval, whilst the latter are expressions of personal opinion. The whole reminds one, to a certain extent, of the modern story

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magazine in so far as every article in the first number ends abruptly with the promise of a continuation " in our next."

The official section opens with the first part of a study of the theoretical conditions affecting the life of barrels—gun, trench mortar, rifle and pistol—and the effect of their deterioration on fire control. In its continuation, no doubt, this article will become very technical. It starts, however, with another complaint as to the indifference of the professional soldier to this important matter. Apparently also our old friend, the " business man," is to be found in Germany, as elsewhere. He seems to have claimed that such matters as the construction of ordnance of all sorts would meet with no difficulty if it were placed in the hands of the " business man." The author of the article, however, maintains that the German business man combines a similar indifference to matters scientific with a profound ignorance of the fundamental principles of war.

The study of ballistics is one which is allied to many subjects in civil life. It has, therefore, received adequate treatment, but the problems of the construction and the life of barrels have no counterpart elsewhere and rest merely on rule of thumb. Explosions and indifferent shooting are taken as a matter of course, and not as a reason for more profound study of the underlying causes. The problem implies finding a proper balance between strength and weight on the one hand, and muzzle velocity and ease of handling on the other. In discussing the destructive forces to be investigated, the author mentions chemical, mechanical and merely thermal theories which have been advanced to account for the wear in the bore. He inclines to accept the latter. Apparently it has been customary in the German service to cast barrels as unfit for further use upon a rule founded on a loss of muzzle velocity. It is considered that this rule is not a wise one and that a loss of muzzle velocity may be noticeable in a barrel which will yet give a good pattern. Destructive forces are then classified, and that which acts upon the lands in consequence of the resistance of the projectile to taking up the rifling is discussed in some detail, in the middle of which the article breaks off.

The next article, of much more interest to the Corps, is one on coast fortification in sand dune country. The article opens with a geological discussion upon the formation of dunes, upon the effects of land and sea winds and a general idea of these matters is well explained by the aid of diagrams. It would seem that German permanent coast fortification has, in many cases, suffered from being masked by rising sand banks, and particularly in the case of such small works as machine-gun emplacements. Hedge and bush screens, partly to arrest the flow of the sand, and partly to break the force of the wind, are dealt with in the text and by diagram, and again the subject is broken with an abrupt reference to more " in our next."

The unofficial section begins with a study of the problem of the mass manufacture of arms, especially of small arms. Before the war such matters were in the hands of State factories, which had little, or no, touch with civil firms. In consequence of the war, these State factories have been closed down, and the workmen are largely lost to their subject. The problem which faces Germany is, therefore, to start the

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manufacture of arms in civil factories, and to ensure inter-changeability of parts and due regard to other military requirements. Permanence of type is, for example, emphasized as most important, and as an illustration of the value of this permanence, the German rifle ('98 model) now 24 years old, is quoted as having a long and useful life still before it. The difference between civil and military requirements is emphasized at considerable length and is illustrated by the difference between wheel construction for the ordinary agricultural vehicle and for military transport. Special military requirements are summed up, as ease of handling, durability, effective pattern, and reserve of power.

The next article is a continuation of one which appeared in the last number of *Technik und Wehrmacht* on the attacks on "Position de Nancy, Camp des Romains, Nowo Georgiewsk." In his opening article on this subject Lieut.-General Schwarte described the repulse of the III Bavarian Corps before Nancy. It was withdrawn to recover from severe losses during a period of rest at Metz, but was soon after allotted to General of Infantry Strautz, together with the V Prussian Army Corps, the 33rd Reserve Division (composed half of Prussian and half of Bavarian units) and certain siege formations, and given the task of breaking through the fortified line between Verdun and Toul. The XIV Army Corps and the Bavarian Cavalry Division were entrusted with the task of screening Toul. It would appear that the French were taken aback by this development and an unexpected attack on the 19th November drove them from their position on the heights overlooking the plain of the Woevre. This attack was conducted by the III Bavarian Corps, which was counter-attacked on the 22nd, 23rd and 24th by the French. The counter-attacks seem to have been pushed home with much vigour and were driven off with a good deal of difficulty and severe loss to the Bavarians. General Strautz's scheme now included a left wheel of the III Bavarian Corps, to facilitate which the 6th Division was ordered to take the Camp des Romains. The attack was to be prepared by:—

2 Battalions of Heavy Howitzers
2 ,, 21 cm. ,,
3 28-cm. coast defence mortars
2 30·5-cm. Austrian mortars
2 10-cm. batteries

This siege artillery opened fire at 10 a.m. on the 23rd. Good results were reported by mid-day, and early the next morning it was officially reported that the Camp des Romains and the batteries which were participating in its defence had been silenced, that the fort itself was breached, and that everything was now ready for the assault. Apparently this report lacked real foundation and was not dictated by the result of any reliable reconnaissance. Nevertheless, in view of the situation on the German right, where no success had been obtained, and of the danger of French counter-attacks from the South, it was decided to assault without delay. The 11th Bavarian Infantry Regiment and the 2nd Battalion of the Prussian Pioneer Regiment No. 16 were entrusted with the task. A rapid outline of the situation and of

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the measures to be taken was given to the troops. The author states that the officers of the 6th Bavarian Regiment had no idea of the proper way to conduct such siege operations and comments severely upon the indifference of pre-war German training to a subject, the importance of which had been frequently emphasized in official instructions. The officers seem to have thought the technical instructions delivered to them as so much " Spanish," and what is " Spanish " to a German officer is " Greek " to us. In spite of this lack of previous training, the attack was successful, though accompanied by very heavy losses, and at its most interesting stage we are told that it will be " continued in our next."

The last article is a report for 1902–21 on the doings of the German Survey. Before the War the German Survey was in military hands. Since the War it has become a Civil Department in Prussia and Saxony, while in Bavaria and Würtemberg it remains in the hands of the old military topographical authorities. Their principal task has been to maintain, revise and publish the German 1/100,000 map. The staff for Prussia and Saxony has been cut down to a total of 683, whereas in Austria, where the area to be mapped is less than a quarter, the staff remains relatively very much higher. It would seem that the activities of the Prussian Survey have not been largely curtailed. There is mention of much geodetic computation connected with the Berlin base and its extension by triangulation to Schubin. Observation in the field was carried out at 18 primary and 85 secondary stations. It is interesting to note that in 1914, in the neighbourhood of the fortress of Königsberg, most of the trigonometrical marks were deliberately removed or obliterated. These points are now being remarked, and no fewer than 1885 have been dealt with. A considerable amount of routine levelling has been carried out, and one or two survey publications of value have been issued.

H.St.J.L.W.

MILITÄR WOCHENBLATT.

(*September 23rd*, 1922.)—The leading article consists of a review of a highly technical work on Ballistics, by Dr. Theodor Vahlen, of value only to a limited number of specialists. It is interesting, however, to note that the critic bewails the small number of publications in Germany, dealing with ballistics and similar technical artillery questions, while drawing attention to the wealth of literature that is appearing in other countries, both enemy and neutral. " With a fortunate issue to the war, it was to be hoped that ballistic literature would evince considerable productiveness—unfortunately it has turned out differently."

Considerable prominence is given to a notice of a publication entitled " Five Years of the Independent Social Democratic Party of Dresden," which the critic considers a remarkable contribution on the revolutionary movement. He draws attention to the pacifist activities of certain Social Democrats in Dresden, some of whom bound themselves together as early as January 4th, 1915, to work for peace ; their work in the early

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part of the war was necessarily clandestine, but the split in the Social Democratic party which it produced became the more pronounced as the war continued. In this struggle within the party recourse was had with great effect to pamphleteering, two strident examples of which are quoted. The first, bearing the date May 1st, 1915, begins " For nine months the world-war has now lasted ! Horrors without end has it brought upon mankind . . . " and proceeds to urge a general cry for peace. The second, issued in 1916, also on the 1st May, includes the following " . . . On May 1st we stretched the hand of brotherhood across frontiers and battlefields to the people in France, Belgium, Russia, Serbia and the whole world." England presumably is not specified, as the 1st May means so little to us ; but further on the pamphlet exclaims that the enemy is not the French, Russian or English people, but the German " Junker," the German capitalists, and the German Government. How far these effusions had any real effect in lowering German morale is not alluded to, but they come in useful as pegs on which to hang the argument that the war was not lost by Germany in the field, but at home.

In an article on " The Threatened Rhineland," the writer bewails the lack of attention that is given to the French propaganda campaign, which is said to be laying great stress on the much higher morale of France as compared to the debased " Kultur " of Germany, as evidenced by the war crimes of the " Huns." This campaign is conducted with such cleverness and insistence that even many a good German is perplexed and is inclined to perceive some grain of truth in this " French babble." To counter the French propaganda, the writer urges the evidence of the German " counter-list " (of war criminals on the Entente side) and the results of the Leipzig trials. Unfortunately, the former, though promised by the German Government in May of the year before last, still awaits publication. As regards the Leipzig trials, he only admits their humiliating result because they took place at the bidding of the Entente, and while only Germany is forced to this " the far worse war crimes of the Entente remain unatoned ! " He stresses the fact that the great majority of those arraigned by French and Belgium were acquitted, and says the charges were based on intentional slanders and distortion of facts, with the one and only object of pillorying Germany. The result, he claims, in neutral countries and in America was thus not unfavourable to Germany. The fact that discussion of the question of war guilt has been forbidden in the occupied territory is labelled an unmistakable sign of a guilty conscience, and the writer ends with " Truth Will Out. . . ." This wish will be echoed by those whose *propaganda* he is attacking.

(*October 1st*, 1922.) In an article entitled " Thoughts on Artillery Tactics in the War of the Future," Colonel Freiherr von Weitershaufen first bewails the fact that all practical experiments in this direction are as good as prohibited to the Germans, and that he must rely on inspirations gathered from personal experience and the study of military literature. After some platitudes on artillery control, he states that the World War produced the centralized control of all batteries under one divisional artillery commander, while the higher formations only

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retained control of the heaviest calibres. He then proceeds to state that in the late war two new weapons were developed, which will influence also artillery tactics in the next war, namely bombing squadrons and tank artillery. In his opinion bombing squadrons are indicated as suitable to take the place of heavy artillery, particularly for attacking rear areas. The question, therefore, requires particular study whether the construction of heavy artillery is worth while and whether bombing aircraft may not perhaps produce more devastating results. But if bombing squadrons are called on to undertake to a great extent the rôle of the heavy and heaviest calibres, then their employment must be taken into consideration in the problem of artillery fire direction. On the other hand, the increasing importance of fighting in the air implies stronger defence by anti-aircraft guns. Every division will have its own anti-aircraft artillery under a single A.A. artillery commander, since the tasks of this arm have nothing in common with those of the other guns.

Arguing thus, the writer deduces that artillery of the future will consist only of medium and light calibres for support of the infantry fight, calibres that suffice for gas attacks, a form of fighting which in his opinion is destined to play a great, if not a decisive rôle. As small calibres he includes guns up to 10-cm. inclusive, and as medium up to 18-cm. inclusive. He advocates batteries of only 3 pieces, in order that full advantage may be taken of the ground, or batteries of 6 pieces divisible into two completely independent half-batteries.

He then lays stress on the necessity for observation personnel, allotting 20-30 men for this to each half-battery. For the artillery commander in modern war all the aids possible are demanded to ensure efficient artillery direction, including detachments for flash-spotting, sound-ranging, mapping, meteorological observation, aircraft and balloons ! Some light-armoured caterpillars, for ammunition supply to critical points of the battle which are subjected to particularly heavy fire, come also into his category of artillery necessaries.

He then proceeds to discuss tanks as the form of artillery which will actually accompany the infantry in the fight. Tanks will only be capable of giving adequate support to the infantry in the assault when the latter have gone beyond the reach of their " battle artillery," and the latter have, by changing position, only been able to bring a portion to their support. Tanks, being destined for the destruction of machine-gun nests and other positions that are offering stubborn resistance, can only carry out this rôle satisfactorily if they form part of the attacking infantry and under one united command. In this way he allots tank squadrons, together with light trench mortars, " etc.," under the commander of the infantry regiment.

Summarizing, of the four groups he has indicated, he insists that the " battle artillery " and bombing squadrons must work closely together, under the single direction of the artillery commander ; A.A. artillery works independently and tank artillery in close co-operation with the infantry.

He concludes by referring to the lessons of the fighting on the Loire, in 1870–71, and of the late war to point the moral of the main principle

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of artillery tactics, viz., to pave the way for the infantry to victory. He foresees that in the war of the future the infantry will, only after the war has gone on some time and they have sustained heavy losses, realize that their success depends on the protection of their own guns.

The subject of the war criminals is brought up again in this number in an article attacking the *Indépendance Belge*. The latter has aroused the writer's wrath by criticizing the inadequacy of the sentences on certain war criminals such as Neumann, Dithmar, Boldt, etc., and by commenting strongly on the German attitude towards these criminals, whose conduct won the applause of the reactionary and chauvinistic elements of the German nation. After summarizing shortly, and in his own way, the evidence and sentences in certain of the cases, the writer proceeds to accuse the Belgian paper of bringing forward a heap of lies in connection with an important international question, and then drags in "the mendacious foundation of the whole Versailles Treaty."

He concludes by saying that to combat this before the whole world with all means at their disposal is one of the most important questions of the present which confront the German nation for the sake of its future.

(*October 11th*, 1922.) In a notice of the ex-Crown Prince's book of reminiscences of the war, Major-General von Borries first points out that there is no doubt that the book is the result of the ex-Crown Prince's own pen, and that the writer, Karl Rosner, has only been called in at a few points in the book. After some eulogistic preliminaries and references to the " incomparable German army of 1914," as well as to the " tired, but unbroken heroes " of the retreat at the end, the critic describes how the ex-Emperor admonished the ex-Crown Prince, on his promotion to the command of the 5th Army at the beginning of the war, saying that " what his chief of staff advised, that he must do." Von Moltke apparently then had his say, praising his military perception, but adding that he must bear the responsibility even though he carried out the advice of his chief staff officers. The writer then remarks that the ex-Crown Prince's military education and training had furnished him with insufficient grounding for the leading of an army, and so it is to be assumed, and is also brought out by the book itself, that in the early part of the war he depended on his capable chief staff officer, who, besides, had been his instructor in the General Staff up to the war. The book also shows that by degrees the ex-Crown Prince developed his own independent opinions so that at last, in the course of the " unsatisfactory " operations before Verdun in 1916, he came into sharp opposition with and broke with his Chief-of-Staff. He seems to have been able to hit it off better with Colonel Count von der Schulensberg, who was his right-hand man later. He seems to have hit it off with the Hindenburg-Ludendorff combination at German G.H.Q., who, as the writer rather naïvely remarks, gave heed to the fact that they were dealing, not only with an Army Commander, but also with the heir to the Throne. It is evident that the book has been based on a careful and comprehensive diary with due regard to the war literature which had already appeared both in Germany and elsewhere. The critic gives the ex-Crown Prince credit for being able to keep distinct the

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appreciation which guided him in the actual stages of the fighting and the judgments at which he has arrived since. Naturally Verdun occupies the greater part of the book; after referring to the severe criticisms of the ex-Crown Prince on the part played in that phase by the German G.H.Q., and its dire results, the critic remarks that another question arises, why the Crown Prince, who perceived the futility of that struggle earlier than his Chief-of-Staff and the German G.H.Q., did not use his influence and position to bring the Verdun operations to an end.

A page and a half of this issue are devoted to two articles of no military interest, both of the style of abuse of all things French to which one is getting used. The first attacks the French Government, saying that it is hindering the reconstruction of the devastated areas, and that all sorts of swindles are being perpetrated, on the principle that nothing matters as "the Boche must pay for it all." The other article is a further diatribe on the Leipzig trials, ending up with a reference to the "early issue of the official German counter-list" which is to give the right information on the true war criminals!

E.G.W.

THE MILITARY ENGINEER.

THE *Military Engineer* for January–February, 1923, publishes an address delivered by General Lansing H. Beach, before the Second Annual Convention of the United States Highway Education Board on the "Rôle of Highways in National Defence." General Beach points out that national defence does not involve solely protection against an invader, but includes the "preservation of our social and economic life from internal disorders." For defence against an invader the coast line is divided into sectors, in each of which there would be mobilized, in case of emergency, a force varying in strength with the importance of the sector. Acting from a suitable centre, the force demands good roads, and for the passage of tanks and mobile artillery the bridges must be capable of supporting weights of 20 to 30 tons. For protection from internal disorders the General considers the case in which the rail-roads might fall into the hands of elements of disorder. Careful schemes for the mobilization of motor transport have been prepared, but these would be of little avail if the roads which are required are either non-existent or in such condition that they are not serviceable. The War Department has prepared for the Bureau of Public Roads an outline of a system of roads covering the entire country which it believes should be developed for military purposes.

VOINA I MIR.

The Institution has recently received the 4th number of *Voina i mir* (War and Peace), a Russian military magazine published in Berlin, by the "Phalanx"-Verlag. The editor is Lieut.-General (of the General Staff) Professor A. K. Kelchevski, and he is assisted by Lieut.-General Borisov, Colonel Kolossovski, Major-General Noskov

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and others. The magazine consists of 240 pages, is exceptionally well bound, well printed and well illustrated. In an opening address the Professor appeals to Russian officers and soldiers to study military science and the art of war. In the great war his countrymen, and especially their senior commanders, were found wanting. Millions of sacred graves in the labyrinths of East Prussia, in the low-lying marshes of Poland and Galicia, in the wooded Carpathians, the solitary heights of Armenia and Turkey, the vine-clad fields of Champagne and the fever-stricken lands of the Salonica front cry out to them to blot out the faults of ignorance. The journal is unpolitical, its pages are open to all branches of military knowledge, but no politics.

In an article entitled "Dangerous Opinions," Professor Kelchevski attacks General Borisov for opinions published in a recent number of the *Vocnnii Sbornik*, that two fundamental modifications in the theory of the art of war, revealed by the experience of the war of 1914–18, are (i) that due to the increase in the power of resistance of small forces, and (ii) the influence of economic localities as objectives on plans of campaign—the first a tactical change, but one which must also strongly influence strategy, the second more nearly a purely strategic one. As regards the first it is claimed that "the increased power of resistance, even of very small forces, led to the lengthening of the active fronts." "It was not the want of munitions which led the belligerent armies into the so-called *position* warfare, but the extraordinary increase—even to the extent of a machine-gun replacing a company—in the power of resistance of the troops." It appears that, during the war, General Borisov served in the strategic branch of the Chief of the Staff of the Russian armies, and on this discovery, of the increased power of resistance of the troops, the Professor lays the blame for a policy which extended the Russian forces along wide lines of continuous trenches, a two-battalion regiment holding a front of 6 versts, and a division from 15 to 20 versts. His own regiment, the 2nd Finland Rifle Regiment, of two battalions, on a 6-verst front, beat off a nine days' attack by the Germans in December, 1914, when their losses were 60 per cent. of their strength, and later they held a similar front for 95 days without relief. No wonder that such experiences kindled among the soldiers a distrust in the capability of their leaders, a distrust which in the revolution led to bewilderment and cries for peace. In June, 1915, the General went to France and found the 70th French Infantry Division, near Arras, occupying a front of 1½ km., the men getting only four days out of 24 in the front trenches, and an English Corps with divisions occupying 2 km. sections, with the men in the trenches for only three days in 30. These arrangements were sound and the others unsound, for, however much the power of weapons may have increased, it is the man that matters in the long run, the man whose physical and moral forces have their limits, which fall rather than rise with the increase in the volume of fire. Our author ridicules the idea of the machine-gun replacing the company, for then might France reduce her army to four divisions and devote the savings in her budget to premiums for the improvement of the birth-rate. The widely extended weak formations in the unimportant sectors resulted in inadequate forces in the decisive

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sectors, and the cries for assistance from the former led to a further weakening of the latter, so that in the whole war not once was a result obtained which could be called decisive. In future wars, we must contemplate, not long defensive lines, but how to develop to the full the resources of the country for the delivery of lightning-like strokes and the reinforcement with fresh forces, not where we are weakest, but where things are going well. The present-day fight rapidly wears out the moral and physical strength of the combatants, and the writer considers that those organizing an attack should provide for it double or even treble the numbers required by calculation for a successful operation. Overwhelming success in the more important sectors is the best support which can be given to sectors of secondary importance. But the troops assigned to these latter sectors must not be unduly extended and must be so well supported by reserves that they can change rounds, if possible, every three or four days. General Borisov's second discovery is that the war showed that the increased power of resistance of an enemy requires now, not only the capture of his capital and the destruction of his active forces, but also the fullest and most rapid destruction of his means of equipping and feeding these active forces. "What hindered us," he writes "at the very beginning of the war, instead of the fruitless and expensive invasion of East Prussia, from making a surprise attack upon the mining district of Silesia? Nothing. Our geometrical strategy and our ignorance of the economic section of the Art of War." General Kelchevski allows that a well-organized air force may now destroy an enemy's industrial centres on the very first day of war. But for a plan of campaign, as contemplated by General Borisov, the objective must ever remain the destruction of the active forces of the enemy. He ridicules the idea of an invasion of Silesia, which could have led only to disaster. General Borisov considers himself a connoisseur of the Napoleonic epoch and yet he forgets Napoleon's dictum "Never uncover your line of communications—this is the A,B,C of military science." This number contains well-illustrated articles on "The German Signal Service in Wartime," "Gliding," and "Tanks," and over 12 pages are devoted to a review of Major Victor Lefebure's book on chemical strategy in war and peace, *The Enigma of the Rhine*.

VOINNA-INJENERNA BIBLIOTEKA.

ANOTHER new publication of considerable interest to Military Engineers is the Bulgarian *Voinna-Injenerna Biblioteka* (The Military Engineering Library) of which we have received the first three numbers. Articles are published on the following subjects:—"The Engineers During the War," "The Influence of Technical Equipment upon Strategy," "Mutual Induction and the Means of Removing It," "The Principles of Fortification in Trench Warfare," "The Technical Instruction of Engineer Officers," "Concrete and Ferro-Concrete in Fortification," "The Action of the Troops in the Crossing of Large Rivers," "Removable Girder Bridges." Many of the articles, and especially that last mentioned, are liberally illustrated.

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THE

MONTHLY SUPPLEMENT

TO THE

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THE QUARTERLY LIST.

AT a recent meeting of the Council of the Institution of Royal Engineers it was decided that the Alphabetical Lists of Active and Retired Officers of the Corps shall, from April next, be included in the *Royal Engineers Quarterly List*, and the separate annual booklet will not again be published.

THE R.E. JOURNAL.

REWARDS to the value of £14 6s. have been granted by the Council of the Institution of Royal Engineers for original articles which were published in the *R.E. Journal* for November and December, 1922.

THE R.E. BAND IN 1922.

DURING the year 1922 the R.E. Band, apart from its purely Corps duties in Chatham and neighbourhood, carried out a fairly full programme of public engagements. At the conclusion of the winter concerts at Margate they played for ten days during the Easter holidays at the Pavilion and Winter Gardens, sharing the honours with many prominent London performers. Writing of the very appreciative audiences at the Bank Holiday concerts, where the staircases and gangways were crowded and every available seat occupied, a London evening paper naïvely recorded the fact "that good music, well played, always tells." Various municipal seaside engagements included a further two weeks at Margate, two weeks at Hastings, six weeks at Worthing and one week at Ramsgate. In each of these places the performances received unstinted praise in the local papers, the high artistic qualities of the various soloists being especially appreciated. The Band week at Aldershot was a brilliant success, and among others an unusual number of retired officers of the Corps attended the various functions. Somewhat similar engagements, but on a smaller scale, were successfully carried out at Cambridge, Cranbrook, Gosport and Sheerness. The year was especially remarkable for the attendance of the Band at the unveiling ceremonies of three memorials to Comrades who fell in the Great War. All those who were present when the monument at Chatham was unveiled will have carried away with them the memory of how greatly the playing of the Band contributed to the impressiveness of that beautiful ceremony. It will be a matter of satisfaction to many readers to learn that the Band also played at the unveiling ceremonies, in the halls of the Institutions of Civil and Electrical Engineers, of their respective memorials. The Band also played at Lords for the R.A. *v.* R.E. match. During the year two concerts were given in London at the Queen's and the Wigmore Halls. The attendance at the latter of these showed a considerable improvement on that of the earlier one, and we give below the programme of music, all the items of which elicited repeated applause from a very appreciative audience. Altogether Mr. Neville Flux is to be congratulated on the high

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standard of excellence maintained by the Band during the past year. That its appearances in London during the last few years have been less frequent than formerly is due to the increased cost of railway travelling, the revised scale of fees and the competition of many foreign and American Jazz orchestras which are now performing at the various social functions at which our Band and orchestras of similar calibre were so deservedly popular in pre-war days.

PROGRAMME OF CONCERT.

Wigmore Hall, Wigmore Street, London, W.

Wednesday, 29th November, 1922. 3 p.m. to 4.30 p.m.

PART I.

1. OVERTURE ... ... "Tam-o'-Shanter" ... ... *Drysdale*
2. SYMPHONY ... ... No. 1 in D Major (Op. 60) ... ... *Dvorák*
   1. Allegro non tanto. Più tranquillo.
   2. Adagio. Poco più animato.
   3. Scherzo. (Furiante) Presto.
   4. Finale. Allegro con spirito. Poco sostenuto. Presto.

INTERVAL.

PART II.

3. SUITE ... ... "Les Deux Pigeons" ... ... *Messager*
   1. Entrée des Tziganes. 2. Scène et pas des deux pigeons. 3. Thème et Variations. 4. Divertissement. 5. Danse Hongroise. 6. Finale.
4. ENTR'ACTE ... ... "Londonderry Air" ... ... *Morris*
5. DANSE HONGROISE ... "Czardas, No. 5" ... ... *Michiels*

GOD SAVE THE KING.

Director of Music ... ...LIEUT. NEVILLE FLUX, F.R.A.M.

THE LATE LIEUT.-COLONEL H. S. HASSARD.

THE funeral of Lieut.-Colonel Henry Somerset Hassard, the Royal Berkshire Regt., took place at Hoddesdon Cemetery on Thursday, 4th January. The deceased, who was 70 years of age, died at Folkestone on December 30th from heart failure, following an operation. He was the son of the late Major-General F. C. Hassard, C.B., R.E., and grandson of Major-General John Hassard, C.M.G., R.E., and brother of the late Lieut. F. N. Hassard, R.E. The deceased received his commission in the year 1873, and he served in India, Bermuda, Cyprus, Malta and various home stations. He retired in 1896 and in 1910 married Julia Tufnell, widow of Mr. J. R. Bell, who survives him. He resided in Hoddesdon for many years.

At the outbreak of the War he offered his services, but owing to age was not accepted. He then undertook work at munition and aeroplane factories. The funeral service was conducted by the Rev. W. J. Harvey (Vicar of Great Amwell), whose church he frequently attended.

R.A. v. R.E. MATCHES—1923.

Racquets and Billiards.—The annual matches at Racquets and Billiards, *versus* the Royal Artillery, will take place at Woolwich on Wednesday, 14th March this year.

Officers willing to compete for inclusion in the teams should communicate direct with the following officers:—

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Racquets.—Lieut.-Colonel B. L. Eddis, D.S.O., R.E. (Hon. Sec., R.E. Games Fund), Room 229, War Office.

Billiards.—Major G. Master, D.S.O., R.E., R.E. Mounted Depôt, Gibraltar Barracks, Aldershot.

Golf.—The Golf match *versus* the Royal Artillery will take place at Sandwich, by kind permission of the Royal St. George's Golf Club, between 21st and 26th April this year.

Officers whose handicap is "six" or better, and who are willing to compete for inclusion in the R.E. team, should communicate direct to Lieut.-Colonel B. L. Eddis, D.S.O., R.E. (Hon. Sec., R.E. Games Fund), Room 229, War Office.

R.E. DRAMATIC CLUB.

IT is some time since the R.E. Officers' Dramatic Club has faced the footlights, but when the members did so on Tuesday and Wednesday, the 19th and 20th December, 1922, at Brompton Barracks, Chatham, in aid of the Mayor of Gillingham's Unemployment Fund, they were given the most enthusiastic reception. They had the distinction of playing an entirely new and original farcical comedy, written by one of the members, Capt. J. B. H. Doyle, R.E., and both performances were a brilliant success. Entitled "The Fool," the play centres round a December day in the life of visitors at a Swiss Hotel. Amongst the visitors are a couple of crooks, a fascinating war-widow who is a real good sort, a henpecked business man, his wife, daughter and nephew, and the strong man of the party (Christopher James Ashton), who is efficient to his finger-tips, and makes a success of everything save his love-making. In order to win the heart and hand of the business-man's daughter, Dorothy Plapple, "C.J." decides to model his behaviour on that of the nephew, who is more than a bit of a clumsy fool. However, the love affairs of the nephew (Jack Somersdown) with the pretty widow (Molly Iredale) are not running as smoothly as he would wish, and he decides to imitate "C.J." The idea is admirably worked out, and into the comedy the author has introduced wit and humour that kept the audience laughing all the time. At the end of the performances, Capt. Doyle was given quite an ovation. The comedy was produced by Colonel H. B. Jones, C.B., who directed a highly-efficient cast. The feminine rôles were admirably sustained. Mrs. Garforth, and Capt. F. I. de la P. Garforth, R.E., were well chosen for the parts of Mr. and Mrs. Toon, the two jewel thieves; Mrs. Halifax did well as Mrs. Plapple; and Mrs. Hasted made a winsome daughter, Dorothy. Mrs. Doyle entered into the spirit of her part well as the war-widow; and Mr. F. C. C. Bradshaw, R.E., made a distinct success of his rôle as the henpecked Henry Plapple. Mr. N. C. D. Brownjohn, M.C., R.E., was highly amusing as Jack Somersdown, and he and Capt. Doyle (the author playing the part of Christopher James Ashton) acted as admirable foils to one another. Two minor characters as gendarmes were taken by Mr. D. S. Blunt, R.E., and Mr. E. S. de Brett, R.E. Prior to the performances and during the intervals a portion of the band of the Royal Engineers played under the conductorship of Serjt. F. E. Ralph.

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Football.

R.E. OFFICERS' ASSOCIATION FOOTBALL.

THIS team returned in good form after Christmas leave and played the T.B., R.E., on Saturday, 13th January, on the latter's ground. The T.B. were short of two players, and the officers were without the services of Steedman at centre half. The T.B., however, took the lead and scored quite early; shortly afterwards Masters equalled, and scored again just before half-time. In the second half the ball kept mostly in the T.B.'s half of the ground, and after about 20 minutes Masters scored a third time.

Result.—R.E. Officers, 3; T.B., 1. Golden, Lamb and Masters played a splendid game.

Team.—Oborne; Lamb, Blagden; Barker, Gurnhill, Blakeney; Hutchins, O'Donnell, Masters, Golden (captain) and Chevis.

RUGBY FIXTURE LIST.

FIRST XV.

DATE.	OPPONENTS.	GROUND.	RESULT.
1923.			
Sat., Feb. 3rd ...	Old Whitgiftians	Croydon	
Sat., ,, 10th ...	R.M. College	Chatham	
Sat., ,, 17th ...	U.S. (Devonport)	Devonport	
Wed., ,, 21st ...	R.M. Academy	Woolwich	
Sat., ,, 24th ...	U.S. (Portsmouth)	Portsmouth ...	
Wed., ,, 28th ...	Rosslyn Park	Richmond	
Sat., Mar. 3rd ...	Old Whitgiftians	Chatham	
Sat., ,, 10th ...	Old Emanuels	Chatham	
Wed., ,, 14th ...	Royal Naval College	Greenwich	
Sat., ,, 17th ...	Old Merchant Taylors	London	
Sat., ,, 24th ...	Edgware	Chatham	
Wed., ,, 28th ...	Blackheath	Blackheath ...	
Sat., ,, 31st ...	London Irish	Norbiton	

"A" UNITED SERVICES XV.

DATE.	OPPONENTS.	GROUND.	RESULT.
1923.			
Sat., Feb. 3rd ...	Tonbridge Town	Tonbridge	
Wed., ,, 7th ...	R.M. Academy	Woolwich	
Sat., ,, 17th ...	Old Dunstonians	Chatham	
Wed., ,, 21st ...	R.M. Academy	Chatham	
Wed., ,, 28th ...	St. Mary's Hospital	London	
Wed., Mar. 7th ...	St. Mary's Hospital	Chatham	
Sat., ,, 10th ...	Hon. Artillery Co.	Chatham	
Sat., ,, 17th ...	Dartford	Chatham	
Sat., ,, 24th ...	St. Mary's Hospital	London	

Corps Fixtures are shown in black type.

G. D. DE'ATH, *Capt., R.E., Hon. Secretary.*

Hockey.

FIXTURE LIST.

DATE.	CLUB.	GROUND.	RESULT.
1923.			
Sat., Feb. 3rd ...	Tulse Hill	Chatham	
Wed., ,, 7th ...	Philistines	Richmond	
Sat., ,, 10th ...	Kenley	Chatham	
Wed., ,, 14th ...	R.M.A., Woolwich	Chatham	
Sat., ,, 17th ...	R.M.C., Sandhurst	Chatham	

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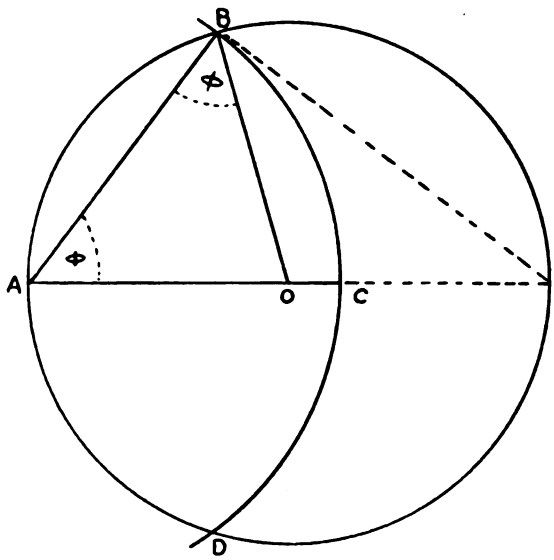
HOCKEY FIXTURE LIST 1923 (*continued*).

DATE.	CLUB.	GROUND.	RESULT.
Wed., ,, 21st ...			
Sat., ,, 24th ...	Teddington	Bushey Park ...	
Wed., ,, 28th ...	Royal Corps of Signals	Chatham	
Sat., Mar. 3rd ...	Bromley	Bromley	
Wed., ,, 7th ...			
Sat., ,, 10th ...	Staff College	Chatham	
Wed., ,, 14th ...	St. Thomas's Hospital	Away	
Sat., ,, 17th ...	Southgate	Chatham	
Wed., ,, 21st ...	R.N.C., Greenwich	Chatham	
Sat., ,, 24th ...			

Problems.

PROBLEM 57. (Solution by Lt.-Col. H. L. Lewis, D.S.O., R.E.).

Given a circle of radius r, it is required to find the radius of another circle which, described with its centre on the circumference of the given circle, shall divide the latter into two equal areas.



O is the centre of the given circle. $OA = OB = r$.

Let A be the centre of the circle whose radius is required, and let $AB = AC = x$.

Let $\angle BAO = \angle ABO = \phi$.

Then the area $ABCD = \frac{\pi r^2}{2}$.

But area $ABCD = 2 \times \{\text{sector } A\overset{\frown}{BC} + \text{sector } O\overset{\frown}{AB} - \Delta ABO\}$.

$$\therefore \frac{\pi r^2}{2} = 2 \times \{\tfrac{1}{2} x^2\phi + \tfrac{1}{2} r^2 (\pi - 2\phi) - \tfrac{1}{2} r^2 \sin(\pi - 2\phi)\}$$

$$= x^2\phi + r^2\pi - 2r^2\phi - r^2 \sin 2\phi,$$

but $$x = AB = 2r \cos\phi.$$

$$\therefore -\frac{\pi r^2}{2} = 4r^2\phi \cdot \cos^2\phi - 2r^2\phi - r^2 \sin 2\phi = 2r^2\phi(2\cos^2\phi - 1) - r^2 \sin 2\phi$$

$$2\phi \cos 2\phi - \sin 2\phi + \frac{\pi}{2} = 0.$$

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For 2ϕ write θ,

then $$\sin\theta - \theta\cos\theta - \frac{\pi}{2} = 0.$$

To solve this equation to any required degree of accuracy, use Newton's method of approximation.

Let $$f(\theta) = \sin\theta - \theta\cos\theta - \frac{\pi}{2} = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots(1).$$

Then $$f'(\theta) = \theta\sin\theta \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2).$$

Let a be an approximate value of θ, and let $\theta = a + \delta$, where δ is small.

Then $$f(\theta) = 0 = f(a+\delta) = f(a) + \delta f'(a) + \frac{\delta^2}{\underline{2}} f''(a) + + \text{etc.},$$

And since δ is small, then approximately $f(a) + \delta f'(a) = 0$ (neglecting δ^2 and higher powers).

$$\therefore \quad \delta = -\frac{f(a)}{f'(a)}.$$

By successive applications of this method, a close degree of accuracy is very quickly obtained.

In the case in question, it is evident from the nature of the problem, that ϕ, expressed in degrees, lies between 45° and 60°, and is nearer to the latter than to the former.

Take 55° as our first approximation for ϕ, so that 110° is our first value for a. Our error cannot exceed 5° for ϕ or 10° for θ, and as 10° is $\frac{1}{6}$th radian approximately, δ will necessarily be small.

$$a = 110° = 1{\cdot}9198622 \text{ radians.}$$

Substituting in equations (1) and (2),

$$f(a) = {\cdot}9396926 + {\cdot}6566316 - 1{\cdot}5707963 = {\cdot}02553,$$
$$f'(a) = a\sin a = 1{\cdot}8048.$$

$$\therefore \quad \delta = -\frac{{\cdot}02553}{1{\cdot}8048} = -{\cdot}0{\cdot}415 \text{ radians} = -48'\ 40'', \text{ about.}$$

2nd approximation.

$$a = 110° - (48'\ 40'') = 109°\ 11'\ 20'' = 1{\cdot}9057057 \text{ radians}$$
$$f(a) = {\cdot}9444402 + {\cdot}6263740 - 1{\cdot}5707963 = +\ 0000179,$$
$$f'(a) = 1{\cdot}8004.$$

$$\therefore \quad \delta = -\frac{{\cdot}0000179}{1{\cdot}8004} = -{\cdot}0000099 \text{ radians} = -\ 2''.$$

3rd approximation.

$$a = 109°\ 11'\ 20'' - 2'' = 109°\ 11'\ 18'' = 1{\cdot}9056960 \text{ radians.}$$

(N.B.—Great accuracy of work is required at this stage).

$$f(a) = {\cdot}9444433 + {\cdot}6263533 - 1{\cdot}5707963 = +\ {\cdot}0000003.$$

$$\delta = -\frac{0000003}{1{\cdot}8} = -\ {\cdot}00000017 = -\ 035''.$$

This correction is not worth making, as we have reached the last figure of our 7-figure tables, and cannot consider this last figure reliable. Our final value of θ, viz., 109° 11' 18", will not be more than ·1" from the true result, and will probably be nearer.

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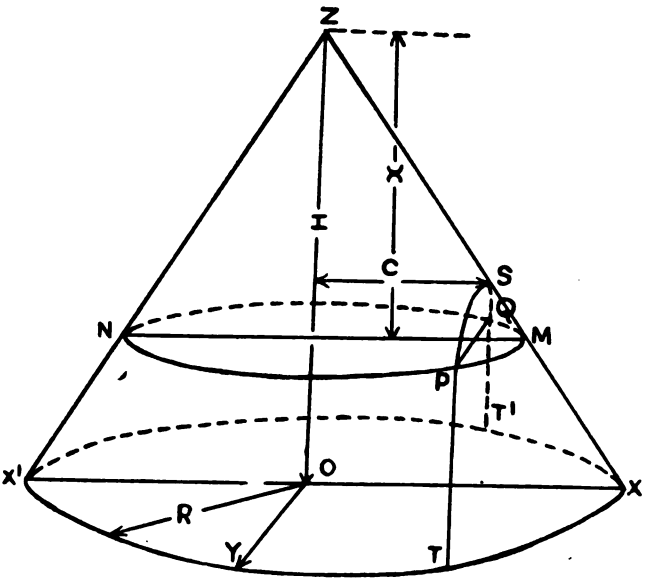
$$x = 2r\cos\frac{109^\circ\ 11'\ 18''}{2} = 2r\cos 54^\circ\ 35'\ 39''$$
$$= 2 \times \cdot 5793642 \times r$$
$$= 1 \cdot 1587284 \times r,$$

with limiting error, due to $\frac{1}{20}$th second of about $\cdot 0000004 \times r$.

This result is near enough for most practical purposes; if greater accuracy is required use 10-figure tables.

PROBLEM 64. (Solution by Lieut. K. H. Tuson, R.E.).

Find the volume of the frustrum of a right circular cone (diameter of base 2 R and height H) cut off by a section perpendicular to the circular section, at a distance (c) from a parallel section through the vertex.



Consider a section NPMQ parallel to the base at a distance x from the vertex.

Let TPSQ be the cutting section. Then distance of S below the vertex is c H/R.

Let r be the radius of the circular section, NPMQ.

Then the area of the circular segment PMQ is

$$r^2\cos^{-1}\frac{c}{r} - c\sqrt{r^2 - c^2},$$

where $r = x\mathrm{R} \div \mathrm{H}$.

The volume, therefore, of an elementary lamina of height δx is

$$\left(r^2\cos^{-1}\frac{c}{r} - c\sqrt{r^2 - c^2}\right)\delta x,$$

and consequently the volume (TPST') X is

$$\int \left\{\frac{\mathrm{R}^2x^2}{\mathrm{H}^2}\cos^{-1}\frac{c\mathrm{H}}{x\mathrm{R}} - \frac{c\mathrm{R}}{\mathrm{H}}\sqrt{x^2 - \frac{c^2\mathrm{H}^2}{\mathrm{R}^2}}\right\}\delta x$$

(since $r = \mathrm{R}x \div \mathrm{H}$) taken between the limits H and $c\mathrm{H} \div \mathrm{R}$.

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Let $X = \int x^2 \cos^{-1}\frac{cH}{xR}\delta x$. Let $Y = \int \sqrt{x^2 - \frac{c^2H^2}{R^2}}\,\delta x$.

Integrating by parts gives

$$X = \frac{x^3}{3}\cos^{-1}\frac{cH}{xR} - \frac{cH}{3R}\int \frac{x^2\,\delta x}{\sqrt{x^2 - \frac{c^2H^2}{R^2}}}$$

To integrate $x^2 \Big/ \sqrt{x^2 - \frac{c^2H^2}{R^2}}$,

let $x = \frac{cH}{R}\cosh\theta$.

Then bearing in mind that

$$\cosh 2\theta = \cosh^2\theta + \sinh^2\theta = 2\cosh^2\theta - 1,$$

and that $\theta = \cosh^{-1} x\,R/c\,H$.

It will be found that

$$x = \frac{x^3}{3}\cos^{-1}\frac{cH}{xR} - \frac{cH}{6R^2}\,x\,\sqrt{x^2R^2 - c^2H^2} - \frac{1}{6}\left(\frac{cH}{R}\right)^3 \cosh^{-1}\frac{xR}{cH}.$$

The integral Y is a standard form, and is equal to

$$\frac{x}{2}\sqrt{x^2 - \frac{c^2H^2}{R^2}} - \frac{c^2H^2}{2R^2}\cosh^{-1}\frac{xR}{cH}.$$

Inserting the limits of x, viz., H and c H/R, it will be found that the volume is

$$\frac{R^2H}{3}\cos^{-1}\frac{c}{R} - \frac{2cH}{3}\sqrt{R^2 - c^2} + \frac{c^3H}{3R}\cosh^{-1}\frac{R}{c}.$$

Correct solutions have been received as under :—

Problem 61.—Lt.-Col. C. G. Falcon, D.S.O., Major Greer and Capt. W L. Roseveare, M.C.

Problem 65.

A heavy equilateral triangle, of weight W, and each side of length (a) is suspended in equilibrium in a horizontal position by three vertical inelastic weightless cords, each of length (l), which are attached to the angular points of the triangle to a ceiling. A couple whose moment is M is applied to the triangle in its plane. Find how high it will rise.

Problem 66.

Trace the curve $x^2(y+1) + y^2(x+1) + x + y = 0$.

J. M. Wade, *Lt.-Col.*

Births.

CLIFFORD.—On the 31st December, 1922, at 57a, Westwood Road, Southampton, Louise (*née* Phillips), wife of Capt. E. H. M. Clifford, M.C., R.E., a son.

FARLEY.—On the 15th November, 1922, at Queen Mary's Maternity Home, Hampstead, to Helen Christine (Motee), the wife of Capt. E. L. Farley, M.C., R.E., a son.

GRAHAM.—On the 18th January, at 3, Grafton Villas, Gillingham, to Constance (*née* Carew Hunt), wife of J. A. Graham, R.E., a son.

HARVEY.—On the 18th January, in Bermuda, the wife (*née* Beattie) of Lieut.-Colonel C. B. Harvey, R.E., a son (still-born).

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LE BRETON.—On the 1st January, at 29, Lower Seymour Street, W., the wife of Lieut.-Colonel E. P. LE BRETON, R.E. (retired), of Loders Court, W. Dorset, a daughter.

LOCH.—On the 21st January, 1923, at Maymyo, Burma, SYLVIA, the wife of Major GEOFFREY C. B. LOCH, R.E., a son.

McNEILE.—On the 3rd January, at Riant Château, Territet, Switzerland, to the wife of Lieut.-Colonel H. C. McNEILE, M.C., a son.

TILLARD.—On the 2nd January, at 100, Philbeach Gardens, S.W. 5, the wife of Capt. J. A. S. TILLARD, R.C.S., a son.

YOUNG.—On the 28th December, 1922, at 45, Engineers Lane, Gibraltar, to EILEEN, wife of Capt. B. K. YOUNG, M.C., R.E., a daughter.

Marriages.

LATHAM—TURNER.—On the 3rd January, at the Cathedral of the Immaculate Conception, Trinidad, by the Very Rev. Father Casey, O.P., GEORGE HILTON LATHAM, Capt., R.E., elder son of ALEXANDER MIRE LATHAM, to MYRA HILDA TOM, widow of EDWIN SYERS TURNER, Lieut. R.N.V.R.

ROSS—BENT.—On the 12th December, at St. Nicholas', Blundellsands, Liverpool, C. G. Ross, R.E., to MARIE, elder daughter of T. BENT, Esq., of Carlton, Alexandria.

WHITE—WELLS.—On the 17th January, at St. Peter's, Cranley Gardens, S.W., by the Rev. C. S. Woodward, M.C., GEORGE GILMOUR, eldest son of the late W. A. WHITE, and Mrs. White of Cheltenham, to KATHLEEN ESTHER, youngest daughter of the late Colonel HENRY LAKE WELLS, C.I.E., R.E., and Mrs. H. LAKE WELLS, of Drayton Gardens, S.W.

YULE—SLATER.—On the 11th January, at St. Stephen's Church, Gloucester Road, by the Rev. Canon J. R. Denham, of Rochester, assisted by the Rev. Lord Victor Seymour, Vicar, Capt. JACK SEYMOUR YULE, O.B.E., Royal Corps of Signals (late R.E.), youngest son of the late GEORGE SIDNEY YULE, of Calcutta, and grandson of the late Major R. A. YULE, 9th Lancers, to MARGARET PHOEBE, elder daughter of the late CHARLES SLATER, of Calcutta and Guernsey.

Deaths.

DEWING.—On the 19th January, at Wareham, PATRICK ROBERT, second son of Bt. Major R. H. DEWING, D.S.O., M.C., R.E., and Mrs. DEWING, aged five weeks.

GAVEY.—On the 1st January, 1923, at The Croft, Hampton Wick, Sir JOHN GAVEY, Kt., C.B., formerly Engineer-in-Chief of the Post Office, aged 80 years.

HORSFIELD.—On the 21st January, in India, Lieut. R. H. HORSFIELD, R.E., dearly loved third son of Mr. and Mrs. H. HORSFIELD, St. Julian's, St. Alban's.

MERRIMAN.—On the 10th January, at the Cottage, St. Clare Road, Lexden, Colchester, EMILY JANE ANNA ELIZABETH (DOLLY), wife of the late Colonel W. MERRIMAN, C.I.E., R.E.

PEARSON.—On the 28th December, 1922, in Darfur, Lieut.-Colonel HUGH DRUMMOND PEARSON, D.S.O., R.E., Director of Survey, Sudan, and President of the Franco-British Boundary Commission, beloved husband of BLANCHE PEARSON, and second son of the late DAVID RITCHIE PEARSON, M.D., and of Mrs. PEARSON, of Kensington and Beckley, E. Sussex, in his 50th year.

PHILIPS.—On the 17th January, at Seascape, Kingsand, Plymouth, GEORGE JOHN ALEXANDER, eldest son of the late Colonel G. PHILIPS, R.E.

SALMOND.—On the 20th January, at Whaddon House, Bruton, Lady SALMOND, the dearly-loved wife of Major-General Sir WILLIAM SALMOND, K.C.B., Colonel-Commandant Royal Engineers.

STANDING.—On the 22nd January, at Carisbrooke, Brunswick Road, Sutton, Surrey, Major ERNEST SIDNEY STANDING, R.E. (retired), eldest son of the late SAMUEL STANDING, in his 67th year.

Corps News.

Appointments Approved.

Lieut.-Colonel F. S. Garwood to be C.R.E., South Midland Area, Oxford.

Lieut.-Colonel L. R. J. W. Taylor, to be C.R.E., South Western Area, Devonport.

Capt. and Bt. Major J. N. Cash, M.C., to be Adjutant, 43rd (Wessex) Divisional Engineers, Bath.

Major P. de Fonblanque, D.S.O., to be D.A.Q.M.G., Eastern Command.

Capt. A. G. B. Buchanan to be Instructor in Construction at S.M.E., Chatham.

Capt. and Bt. Major G. le Q. Martel, D.S.O., M.C., to be Staff Captain, Fortifications and Works Directorate, War Office.

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Movements at Home.

Capt. and Bt. Major A. V. T. Wakely, M.C., from Christchurch to Staff College, Camberley.
Capt. and Bt. Major G. N. Macready, D.S.O., O.B.E., M.C., from Salisbury to Staff College, Camberley.
Capt. and Bt. Major R. H. Dewing, D.S.O., M.C., from Weymouth District to Staff College, Camberley.
Capt. and Bt. Major B. C. Dening, M.C., from Ireland to Staff College, Camberley.
Capt. and Bt. Major J. N. Cash, M.C., from leave ex-Iraq to Bath.
Capt. and Bt. Major G. le Q. Martel, D.S.O., M.C., from Staff College, Camberley, to War Office.
Major J. C. I. Wood, from Hounslow to Chatham.
Capt. J. H. Mousley, D.S.O., from Iraq (waiting orders), to Chatham.
Capt. R. L. Bond, D.S.O., M.C., from Bath to Aldershot.
Capt. A. G. B. Buchanan, from War Office to Chatham.
Lieut. K. W. Merrylees, from E. and M. Course to Chatham.
Lieut. H. D. Maconochie, M.C., from Ulster to Weedon.
Capt. and Quartermaster A. W. Savage, from Portsea to Monmouth.
Lieut. R. C. Chalmers, A.I.R.E.M., from Gosport to Aldershot.

Arrivals Home.

From Constantinople.—Lieut. J. F. Farewell, on completion of tour of service and to Gosport.
From India.—Lieut.-Colonel F. S. Garwood and Major W. E. Kidner, M.C., on reversion to British Establishment and to Oxford and Preston. Major A. D de R. Martin and Bt. Major J. D. Gemmill, M.C., on leave of absence pending retirement.
From Rhine.—Major O. E. Wynne, O.B.E., and to Staff College, Camberley.

Embarkations.

For India.—Lieut.-Col. P. K. Betty, C.M.G., D.S.O., Majors H. L. Bingay, D.S.O., H. I. Bulkeley, M.C., and Lieuts. G. D. S. Adami, G. K. Cassels, G. W. Harris, C. E. Montague, J. M. Herrold, F. H. R. French, B. H. S. Lloyd, J. R. Simpson, J. M. Lambert, J. S. Forbes, A. R. Churchill, E. J. Palairet, E. H. T. Gayer, and C. D. Reed for a tour of service.
For Sierra Leone.—Major and Bt. Lieut.-Colonel J. Day, D.S.O.

Reversions from the Indian to British Establishment.

Major S. Pemberton, D.S.O., M.C., from January, 1923, and to Bulford.
Major C. W. Bushell, O.B.E., from 1st February, 1923, and to Northern Command
Major W. E. Kidner, M.C., from 24th December, 1922, and to Preston.
Lieut.-Colonel F. S. Garwood, from 1st January, 1923, and to Oxford.

INDIA.

THE following Army Instruction (India) is published at the request of the D.A.A.G.3, A.H.Q., Simla. It will be republished in the revised edition of R.E. Corps Memoranda (India):—

GOVERNMENT OF INDIA.

5th December, 1922.

1005.—REVISION OF THE RATES OF PENSION OF ROYAL ARTILLERY OFFICERS SELECTED FOR CONTINUOUS SERVICE IN THE INDIAN ORDNANCE DEPARTMENT AND ROYAL ENGINEER OFFICERS SERVING UNDER THE 1904 CONDITIONS OF SERVICE.

With reference to paragraph 9 of Army Instruction (India) No. 448 of 1920, it has been decided, with the approval of the Right Hon'ble the Secretary of State for India, that the revised rates of pension sanctioned for officers of the Indian Army in that Instruction and the method of computing those rates shall be extended to Royal Engineer officers serving under the 1904 conditions of service and Royal Artillery officers selected for continuous service in the Indian Ordnance Department who formerly would have received pensions under the rules laid

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down in paragraphs 719–21, Army Regulations, India, Volume I. The above Royal Artillery and Royal Engineer officers shall be allowed to count for Indian element service out of India to an extent not exceeding five years, and shall be permitted to retire after a minimum service of 18 years for Indian pension. No service rendered out of India after an officer has left India finally shall, however, be allowed to count for Indian element.

2. Royal Artillery and Royal Engineer officers above the rank of Lieut.-Colonel who, on retirement from Indian service, have qualified for an Indian pension shall receive pensions as for corresponding ranks of the Indian Army, *i.e.*, at a minimum of £800 a year for Colonel.

3. Royal Artillery and Royal Engineer officers who are now in service shall be allowed the option, which may be exercised at any time before retirement, of electing the revised rules or of remaining under the existing rules.

ARMY DEPARTMENT.

ARMY INSTRUCTION (INDIA).

No. 448 of 1920.

SIMLA, *29th June*, 1920.

448.—REVISION OF THE RATES OF PENSION OF OFFICERS OF THE INDIAN ARMY.

With the approval of the Right Hon'ble the Secretary of State for India, the Government of India have decided that the ordinary retiring pensions of officers of the Indian Army shall be regulated as follows:—

2. Pension will consist of three parts:—

(*a*) a service element based on the officer's total service for Indian pension;

(*b*) a rank element for the rank in which the officer retires;

(*c*) an Indian element for service in the Indian Army.

3. The scale of pensions will be as follows —

(*a*) *Service Element.*—£150 a year after 15 years' service, with an increment of £15 a year for each completed year over 15. The minimum service required for a retiring pension is 18 years.

(*b*) *Rank Element.*—

Rank from which retired.	After completing one year's service in the rank.	After completing each additional year's service.	Maximum rank element.
	£	£	£
Major	12	12	120
Lieutenant-Colonel	150	30	240
Colonel	200	50	390
Major-General	440	50	540
Lieutenant-General	590	50	690
General	740	50	840

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(*c*) ***Indian Element.***—

For service up to and including the rank of Lieutenant-Colonel—

After 18 years' service, £50, rising by £12 10s. a year up to the completion of 24 years' service, and thereafter by £15 a year from 25 to 29 years' service inclusive, making a maximum Indian element of £200.

For service in the rank of Colonel,—£100.

There will be no Indian element for service in the rank of General Officer.

4. The pension of an officer, retiring with less than one complete year's service in the rank from which he retires will be assessed as though he had retired from the rank below.

5. The maximum rates of elements (*a*) and (*b*) together will be :—

Captain and Subaltern	£300
Major	450
Lieutenant-Colonel	600
Colonel	800
Major-General	1,000
Lieutenant-General	1,200
General	1,400

6. The maximum pension of a Lieutenant-Colonel, including elements (*a*), (*b*) and (*c*), will be £800 a year. For a Colonel the maximum will be £900 a year and the minimum £800 a year.

7. For the General Officers the minimum pension will be the maximum of the next lower rank. They will be eligible, on promotion to each rank, for the full service element required for the maximum pension in that rank, *i.e.*, the difference between the maximum pension (paragraph 5) and the maximum rank element (paragraph 3 *b*) of the rank. The maximum pension for General Officers will be the amounts shown against the ranks concerned in paragraph 5.

8. Unemployed service up to and including the 30th June, 1920, will be allowed to reckon as service for pension under the new conditions ; but service thereafter will not so reckon.

9. The revised rates of pension will take the place of the present rates in the case of those officers of the Royal Artillery and Royal Engineers whose pensions are regulated entirely or partially by the rules for officers of the Indian Army.

10. The revised rates of pension will be payable as from the 1st April, 1919, to all permanent regular officers of the Indian Army who, being otherwise entitled, have given paid military service to the satisfaction of the Government of India during the Great War, including officers who, having retired on pension before the War, have been re-employed as officers during the War and have thereafter reverted to retirement. The pensions of the latter officers will be re-assessed on their service prior to original retirement, except in the case of officers serving for increased pension under India Army Circulars, clause 99 of 1893.

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11. Retired officers taken into employment during the War under Army Department letter No. H.-2760, dated the 6th January, 1915 (Appendix "A" to this Instruction), will not draw the new rates of pension while in receipt of re-employed pay and allowances in addition to their pensions.

12. Temporary rank held in the Great War, followed by substantive promotion to that rank, will count as service in the rank towards pension. If the officer receives substantive promotion to a lower rank, it will count as service in that rank. Service in the temporary rank of Brigadier-General, or higher rank, will count as service in the rank of substantive Colonel or lower substantive rank held by the officer on retirement.

13. The new rates of pension are temporary and provisional and will be subject to revision if necessary after the 1st July, 1924, to an extent not exceeding 20 per cent. according as the cost of living rises or falls. After the 1st July, 1924, a further revision may take place every three years; but in the case of an officer who entered the Indian Army before the 1st July, 1920, the pension will not in any case be reduced below that which he would have received under the old scale, service for pension being calculated under the new rules.

14. Illustrations of the method of calculating pensions under these rules are given in Appendix "B" to this Instruction.

15. Officers will be free to elect the revised rules for pension as well as those for leave pay and unemployed pay which will be notified shortly, or to remain under existing rules; but they must be finally accepted as a whole, that is, an officer will not be permitted to elect the existing rates of unemployed pay and the new scale of pensions or *vice versa*.

16. Further instructions will be issued with regard to invalid pensions, and the pensions of military officers on the Supernumerary List who have held important civil appointments.

A. H. BINGLEY, *Major-General.*
Secretary to the Government of India.

WAZIRISTAN GRATUITY.

A CORRESPONDENT asks us to publish a notice that officers who served in Waziristan are eligible for a gratuity under Army Instruction (India) 526 of 1922. He heard of it himself only accidentally and thinks that others, like himself, may be out of touch with Indian Army Instructions.

GENERAL SERVICE MEDAL.

WAR OFFICE, *19th January*, 1923.

THE King has been graciously pleased to approve of a new medal being struck to commemorate military operations, as notified in Army Orders from time to time, otherwise than in East, Central and West Africa, or in India, or on the Indian Frontier. The medal will be known as the "General Service Medal." In each case in which this medal is

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issued a clasp will be affixed denoting the operation for which it is granted.

The medal, with clasp " Iraq," will be granted to all officers and men who :—

(*a*) Served at Ramadi, or north of a line drawn east and west through Ramadi between 10th December, 1919, and 13th June, 1920, both dates inclusive ; or

(*b*) Were present on the establishment of a unit or formation within the boundaries of Iraq between 1st July, 1920, and 17th November 1920, both dates inclusive.

The medal, with clasp " Kurdistan," will be granted to all officers and men who served :—

(*a*) At Kirkuk, or north of a line drawn east and west through Kirkuk, between 23rd May, 1919, and 31st July, 1919, both dates inclusive ; or

(*b*) At Dohok, or north of a line drawn east and west through Dohok, between 14th July, 1919, and 7th October, 1919, both dates inclusive ; or

(*c*) At or north of the advance bases near Akra and Amadia respectively, between 7th November, 1919, and 6th December, 1919, both dates inclusive.

The medal, with clasp " N.W. Persia," will be granted to all officers and men of " Norperforce," and also to those troops on the Lines of Communication from Quraitu, who served west of a line drawn north and south through Teheran between 10th August, 1920, and 31st December, 1920, both dates inclusive.

The medal, with clasp " S. Persia," will be granted to all officers and men who served :—

(*a*) Under the command of Major-General J. A. Douglas, C.M.G., C.I.E., or of Brigadier-General A. M. S. Elsmie, C.M.G., at or in the neighbourhood of Bushire between 12th November, 1918, and 22nd June, 1919, both dates inclusive ; or

(*b*) Under the command of Major-General Sir P. Sykes, K.C.I.E., C.M.G., or of Lieut.-Colonel E. F. Orton, at or in the neighbourhood of Bandar Abbas, between 12th November, 1918, and 3rd June, 1919, both dates inclusive.

Commanding officers will submit claims of serving personnel as follows :—

(*a*) Officers and nurses to The Secretary, The War Office, (A.G. 10).

(*b*) Warrant officers, non-commissioned officers and men to Officers i/c Records.

Officers and nurses not serving, and legatees or next-of-kin of deceased officers or nurses, should apply to The Secretary, The War Office (A.G. 10).

Warrant officers, non-commissioned officers and men discharged, or transferred to the Army Reserve, and legatees or next-of-kin of those deceased should apply to the Officer i/c Records of the regiment or corps with which they last served.

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Extracts from the London Gazette.

TERRITORIAL ARMY.—*42nd (E. Lancs.) Divl. Engrs.*—Capt. H. A. Joly de Lotbinière, M.C., to be Ajdt., *vice* Maj. P. H. Sharpe, M.C., who vacates the appt. 17th Nov. *51st (Highl.) Divl. Engrs.*—2nd Lt. L. G. Smith to be Lt. 9th Oct. *Engineer and Railway Staff Corps.*—Lt.-Col. Sir H. W. Thornton, K.B.E., resigns his comm., 2nd Dec., and is granted the hon. rank of Maj.-Gen. *10th A.A. Bn.*—Lt. A. J. Anido, from Lond. Elec. Engrs., to be Capt. 4th Oct. Capt. A. J. Anido, to be Maj. 2nd Dec. *11th A.A. Bn.*—Maj. A. W. M. Mawby, O.B.E., from T.A. Res., to be Maj. 18th Nov. (Substituted for that which appeared in the *Gazette* of 17th Nov.)

MEMORANDA.—The following retire on an Indian Pension 1st Dec.:—Maj.-Gen. S. H. Sheppard, C.B., C.M.G., D.S.O. Col. A. H. Cunningham. Col. R. J. B. Mair, C.M.G., retires on ret. pay 1st Dec. (1–12–22.)

ESTABLISHMENTS.—The following appt. is made:—SCHOOL OF MILITARY ENGINEERING.—*Chief Instr. in Construction (Cl. Y).*—Bt. Lt.-Col. D. K. Edgar, D.S.O., *vice* Bt. Lt.-Col. H. L. Lewis, D.S.O. 14th Nov.

REGULAR ARMY RESERVE OF OFFICERS.—The following 2nd Lts. to be Lts.:—G. A. H. Buttle, 20th Sept. 1920. W. F. Gardner, 18th Feb. J. R. Caseley, 30th Apr. J. A. Waters, M.M., 25th Oct. G. O. Mitchell, 1st Dec.

TERRITORIAL ARMY.—ARMY POSTAL SERVICE.—Lt. A. S. Langlands relinquishes his commn., 30th Sept. 1921, under A.O. 166/21, as amended by A.O. 332/21, and retains the rank of Lt. *N. Rid. (Fort.) Engrs.*—Lt. G. Jobson resigns his commn., 6th Dec., and is granted the rank of Capt. (5–12–22.)

ESTABLISHMENTS.—SCHOOL OF E.L.—The following temp. appt. is made:—*Instr. (Cl. C.C.).*—Capt. J. H. Dyer, M.C., *vice* Capt. B. B. Edwards, M.C., 23rd Nov.

TERRITORIAL ARMY.—*46th (N. Mid.) Divl. Engrs.*—The following Officers relinquish their commns., 30th Sept, 1921, under A.O. 166/21, as amended by A.O. 332/21, and retain their rank, except where otherwise stated:—Lt. K. N. Moss, O.B.E., and is granted the rank of Capt. Lt. H. Taylor, M.C. Lt. K. M. Mahood. Lt. E. S. Roberts. Lt. L. Robinson, D.S.O., and is granted the rank of Maj. Lt. F. C. Salmon, and is granted the rank of Capt. Lt. A. J. Stubings. Lt. G. M. Mountford. Lt. G. Birks. Lt. A. T. O. Quick, and is granted the rank of Capt. Lt. L. Turner, and is granted the rank of Capt. Lt. S. S. Magee. Lt. T. J. O'Sullivan, and is granted the rank of Capt. Lt. K. G. Griffiths. *52nd (Lowland) Divl. Engrs.*—Lt. D. Adams relinquishes his commn., 30th Sept. 1921, under A.O. 166/21, as amended by A.O. 332/21, and is granted the rank of Capt. *Lanc. (Fortress) Engrs.*—Lt. K. McI. Whyte relinquishes his commn., 20th Sept. 1921, under A.O. 166/21 as amended by A.O. 332/21, and is granted the rank of Capt. (8–12–22.)

CORPS OF ROYAL ENGINEERS.—Maj. and Bt. Lt.-Col. O. G. D. Jones, M.C., is placed on the h.p. list on account of ill-health. 13th Dec. Capt. and Bt. Maj. J. D. Gemmill, M.C., retires on ret. pay, 13th Dec., and is granted the rank of Lt.-Col. The following Lts. to be Capts.:—18th Oct. C. B. T. Gripper, and to remain attd. for duty with the Tank Corps. H. J. Stokes, under Art. 111. R. Warrant for pay and promotion, 1922. H. A. Kenyon, M.C., 11th Nov. F. I. de la P. Garforth, 16th Nov. W. H. Knox, 29th Nov.

TERRITORIAL ARMY.—*2nd Cheshire Field Squadron.*—Alexander John Cope Wilson, to be 2nd Lt. 13th Dec.

MEMORANDUM.—Maj. and Bt. Lt.-Col. O. G. D. Jones, M.C., h.p. list, late R.E., is restd. to full pay whilst empld. with the R.E. 13th Dec. (12–12–22.)

CORPS OF ROYAL ENGINEERS.—Capt. V. E. G. Guinness relinquishes the actg. rank of Maj. 30th June 1921. (Substituted for the notification in the *Gazette* of 14th July.)

REGULAR ARMY RESERVE OF OFFICERS.—Maj. M. S. Koopman, late R.E., to be Maj. 6th Nov., with seniority 31st Aug. 1921. The following 2nd Lts. to be Lts.:—V. M. Harvey, 18th Dec. 1921. A. W. Birker, late K.R.R.C., 18th Sept., with seniority 18th Dec. 1921.

TERRITORIAL ARMY.—*53rd (Welsh) Divl. Engrs.*—Cadet James Richard Godfrey Barter (from the Cambridge University Contgt., Sen. Div., O.T.C.) to be 2nd Lt. 24th July. (Substituted for the notification which appeared in the *Gazette* dated 17th Oct.) *Hants. (Fort.) Engrs.*—Lt. A. L. Bartlett relinquishes his commn., 30th Sept. 1921, under A.O. 166/21, as amended by A.O. 332/21, and retains the rank of Lt. *Lond. Sig. Cos. (A.T.).*—Lt.-Col. E. H. Leaf (Hon. Capt. in the Army), relinquishes his commn., 30th Sept. 1921, under A.O. 166/21, as amended by A.O. 332/21, and retains his rank, with permission to wear the prescribed uniform. *10th A.A. Bn.*—Capt. R. C. Milliken, from Lond. Elec. Engrs., to be Maj., with pay and allces. of a Capt., whilst holding a special appt., 20th Oct. *11th A.A. Bn.*—Capt.

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C. H. S. Evans, O.B.E., from Lond. Elec. Engrs., to be Maj., with pay and allces. of a Capt., whilst holding a special appt. 9th Oct. (Substituted for that which appeared in the *Gazette* of 3rd Nov.) Maj. G. F. Wood, M.C., from T.A. Res., to be Maj. 16th Dec. (15-12-22.)

War Office, 19th December, 1922.

The following is the correct description of the undermentioned, whose name has appeared in the *London Gazette* indicated for the reward specified :—*London Gazette* dated 4th September, 1919. *Belgian Croix de Guerre.*—For Captain Harold Dawe, 141st Army Troops Company, R.E. (T.F.) read Captain Howard Dawe, 141st Army Troops Company, R.E. (T.F.).

TERRITORIAL ARMY.—*50th (North'd) Divl. Engrs.*—Gerald Leopold Thompson, to be 2nd Lt. 1st Nov. (19-12-22.)

COMMANDS AND STAFF.—*G.S.O., 1st Grade.*—Bt. Lt.-Col. F. H. Kisch, C.B.E., D.S.O., relinquishes his appt. and temp. rank of Lt.-Col., 29-11-22. (28-11-22.)

The King has been graciously pleased to command, on the recommendation of the Secretary of State for War, that the following appointment to the Order of the British Empire, which was published in the *London Gazette* on the date stated, shall be transferred to the Military Division of the Order, in terms of the notification published in the *London Gazette* of 27th Dec., 1918 :—

Officers.—Broke-Smith, Major Philip William Lilian, D.S.O., R.E., 8th Jan., 1919. (22-12-22.)

CORPS OF ROYAL ENGINEERS.—Capt. and Bt. Maj. J. W. J. Raikes, is placed on the h.p. list on account of ill-health, 16th Nov. (Substituted for notification of 8th Sept.) Maj. and Bt. Lt.-Col. G. W. Denison, D.S.O., relinquishes A/rank of Lt.-Col. on ceasing to be empld. as C.R.E. 1st Apr.

ROYAL CORPS OF SIGNALS.—Capt. R. Elsdale, M.C., from R.E., to be Capt. 20th Dec. 1921, with seniority 26th June 1917, and precedence next above G. E. Mansergh, M.C.

REGULAR ARMY RESERVE OF OFFICERS.—Lt.-Col. J. D. Gemmill, M.C., ret. pay, to be Lt.-Col. 13th Dec., with seniority 19th July, 1921.

MILITIA.—SUPPLEMENTARY TO UNITS OR CORPS.—Capt. G. E. Rhodes relinquishes commn., 20th Dec., and is granted rank of Maj. (19-12-22).

COMMANDS AND STAFF.—Following relinquish their T/appts. :—*G.O.C.*—Maj.-Gen. Sir T. Fraser, K.C.B., C.S.I., C.M.G., 26th Nov. *G.S.O., 2nd Grade.*—Capt. and Bt. Maj. (now Maj.) P. C. S. Hobart, D.S.O., O.B.E., M.C., 1st Apr. 1919. T/Appt. made :—*Staff Capt.*—Capt. G. E. Grimsdale, *vice* Capt. A. D. Curtis, R.A,. 11th Nov.

CORPS OF ROYAL ENGINEERS.—Maj. J. A. McQueen, D.S.O., M.C., retires on ret. pay, 21st Dec. Capt. and Bt. Maj. E. N. Evelegh, D.S.O., M.C., ceases to be attd. for service with the R.C. of Sigs., 1st May. 2nd Lt. C. M. Singer to be Lt. 22nd Dec.

REGULAR ARMY RESERVE OF OFFICERS.—Maj. J. A. McQueen, D.S.O., M.C., ret. pay, to be Maj. 21st Dec., with seniority 30th Nov. 1916.

TERRITORIAL ARMY.—*44th (H. Counties) Divl. Engrs.*—Lt. W. J. Forward, from 44th H. Counties Divl. Train, R.A.S.C., to be Lt. 23rd Dec. *Cornwall (Fort.) Engrs.*—Capt. C. R. Stephens, M.C., resigns commn., 23rd Dec., and retains rank of Capt. *48th (S. Mid.) Divl. Engrs.*—Lt.-Col. J. L. V. S. Williams, T.D., is retired on completion of tenure of commd., and retains rank of Lt.-Col., with permission to wear the prescribed uniform, 1st Dec.

MEMORANDUM.—Capt. (now Maj.) A. H. C. Trench, C.I.E., to be T/Maj., whilst empld. as a Dep. Asst. Dir.-Gen. of Mil. Works in India, from 5th Aug. 1914 to 27th Oct. 1917. (22-12-22.)

CORPS OF ROYAL ENGINEERS.—Capt. H. J. Stokes having attained the age fixed for compulsory retirement, is placed on ret. pay, 30th Dec. Lt. R. G. M. Wilson, M.C., resigns his commn., 30th Dec., and is granted rank of Capt.

MEMORANDA.—Col. J. Charteris, C.M.G., D.S.O., relinquishes T/rank of Col. on the Staff, on ceasing to be empld. as D.A. and Q.M.G. in India, 27th Dec. Col. J. Charteris, C.M.G., D.S.O., retires on an Indian Pension, 27th Dec., and is granted hon. rank of Br.-Gen. Maj. D. Ogilvie, C.I.E. (now Lt.-Col., ret.) to be T/Lt.-Col. whilst empld. as Asst. Dir. Gen. of Mil. Works in India, from 9th Sept. 1914 to 6th Apr. 1916. Maj. A. D. St. G. Bremner, M.C., to be Bt. Lt.-Col. 30th Sept. Capt. R. C. Lord, M.C., h.p. list, retires on ret. pay on account of ill-health caused by wounds, 29th Dec., and is granted rank of Maj. (29-12-22.)

COMMANDS AND STAFF.—*To be Asst. Dir. of Fortifications and Works.*—Col. J. C. Matheson, *vice* Col. E. P. Brooker, C.B., C.M.G., 1st Jan.

CORPS OF ROYAL ENGINEERS.—Lt.-Col. W. R. Izat, D.S.O., retires on an Indian Pension, 31st Dec. 1922. Capt. T. H. Foster retires on ret. pay 31st Dec. 1922. Lt. J. B. Glubb, M.C., to be Capt. 14th Nov. 1922.

ESTABLISHMENTS.—SENIOR OFFICERS' SCHOOL.—*Instr. (Cl. Y).*—Bt. Lt.-Col. G. F. B. Goldney, C.M.G., D.S.O., relinquishes his appt., and T/rank of Lt.-Col. 1st Jan.

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REGULAR ARMY RESERVE OF OFFICERS.—2nd Lt. R. G. Philipp, to be Lt., 17th Aug. 1922, with seniority 10th Mar. 1921.

MILITIA.—*Postal Section.*—Lt. R. J. Barnes, M.C., relinquishes A/rank of Lt.-Col. 15th Dec. 1922.

TERRITORIAL ARMY.—*55th (W. Lancs.) Divl. Engrs.*—Lt. N. S. Henshaw, M.C., to be Capt. 4th Aug. 1922. *City of Edinburgh (Fort.) Engrs.*—Lt. D. Weighton resigns commn., 3rd Jan., and retains rank of Lt. *Lond. Sig. Cos. (A.T.).*—Capt. J. R. Kingston, O.B.E., relinquishes commn., 30th Sept. 1921, under A.O. 166/21, as amended by A.O. 332/21, and is granted rank of Maj. *11th A.A. Bn.*—Capt. F. C. Clarke, from the Lond. Elec. Engrs., to be Capt. 1st Dec. 1922.

The King has been graciously pleased to confer the Territorial Decoration upon the following officers under the terms of the Royal Warrant dated 13th October, 1920:—*42nd (East Lancs.) Divl. Engrs.*—Hon. Col. W. J. Galloway. *54th (East Anglian) Divl. Engrs.*—Maj. G. C. Walker, O.B.E., M.C.

MEMORANDA.—Following Cols. to be Maj.-Gens. 3rd Jan.:—R. N. Harvey, C.B., C.M.G., D.S.O., J. R. E. Charles, C.B., C.M.G., D.S.O. Col. M. G. Taylor, C.M.G., D.S.O., relinquishes T/rank of Col. on the Staff 1st Jan. Following Colonels retire on ret. pay:—E. P. Brooker, C.B., C.M.G., 1st Jan., and is granted hon. rank of Br.-Gen., Sir S. H. Wilson, K.C.M.G., K.B.E., C.B., 3rd Jan. (2-1-23.)

BAND CONCERT IN LONDON.

A BAND CONCERT will be held in the Wigmore Hall, 52, Wigmore Street, W., on Wednesday, 7th March, 1923, commencing at 3 p.m.

Tickets will be issued free to all serving or retired R.E. Officers for themselves and their friends, on application to:—

Honorary Secretary, R.E. Band,
St. Mary's Barracks,
Chatham.

All tickets will be issued in the order in which applications are made, up to the seating capacity available, estimated at 400. Not more than 40 tickets will be issued to officers stationed at Chatham till after 12th February, but their applications will be registered. For the benefit of officers serving abroad 40 tickets will be kept in hand till 28th February.

After 12th February, if the situation permits, tickets up to two per officer will also be issued free on application to any officer who holds or has held a Temporary, Special Reserve, or Territorial Army Commission in the Royal Engineers. Applications may be made at any time.

It is hoped that any tickets issued and not required will be returned to the Hon. Secretary, R.E. Band, in time for redistribution before the date of the Concert.

The details of the Concert held on 29-11-22 are:—

	Tickets applied for	*Tickets issued*	
Officers serving abroad	18	18	
Other Officers	374	294	(includes 10 in gallery)
R.E.O.C.A.	—	100	
War Office	—	20	

Notices.

STOWE SCHOOL.

THE Authorities of Stowe School are advertising for a BURSAR. Applications for this post, which is a resident one, may be made to the Headmaster. Box 563, Clark's Advertising Service, 57 Mortimer Street, London, W.1.

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SOCIETY OF MINIATURE RIFLE CLUBS.

January, 1923.

AN organizing Secretary is required for the Society of Miniature Rifle Clubs.

Qualifications.—Age not to exceed 45 years on the 1st July, 1923. Must be a good organizer, with a thorough knowledge of business, office work, musketry, and rifle ranges: must be capable of conducting a large rifle meeting, have a knowledge of affairs, and be possessed of tact.

Salary.—Five hundred pounds (£500) a year, with an annual increase, after two years of service satisfactory to the Society, of fifty pounds (£50) a year, up to a maximum of seven hundred pounds (£700) a year, inclusive of all payments except actual expenses incurred in the performance of his duties.

Applications by letter only, with testimonials (not exceeding three in each case) or copies of them, addressed to the Chairman, Society of Miniature Rifle Clubs, Arundel House, Arundel Street, Strand, London, W.C. 2., and marked on the outside "Appointment of Secretary," will be received up to the 15th March, 1923.

THE LATE MAJOR-GENERAL C. J. MOYSEY, C.M.G., COLONEL-COMMANDANT, ROYAL ENGINEERS.

MESSRS. WALTON & Co., of 103, Shaftesbury Avenue, W.1, are proposing, by the special permission of Mrs. Moysey, to issue a portrait of the late Major-General Moysey, at the price of one guinea each copy, if a minimum number of thirty orders are received from subscribers.

MAJOR WAKELY'S NOTES FOR ADMISSION TO THE STAFF COLLEGE.

A REVISED edition of these Notes, which first appeared in the June, 1922, number of the *Royal Engineers Journal*, is being published as a pamphlet by Messrs. Sifton Praed & Co., Ltd., 67, St. James's Street, S.W.1. price 1s. 6d.

DESCRIPTIVE ACCOUNTS OF FOREIGN STATIONS.

THE Singapore and Hong Kong pamphlets have been revised and reprinted and are now on sale, price (members) 6d.; (non-members) 1s. The Sierra Leone pamphlet is in print and will be ready this month. Jamaica, Ceylon, Mauritius and Gibraltar have also been revised and will be published shortly.

R.E. BAND CONCERTS.

R.E. BAND CONCERTS will be held in the R.E. Theatre, Brompton Barracks, from 3 p.m. to 4.30 p.m. on the following dates:—1923: February 6th, 20th, 27th, March 6th, 20th, 27th.

R.E. BAND SUBSCRIPTIONS.

OFFICERS are reminded that the Annual Subscriptions of two days' pay falls due in April of each year.

Undue delay in receiving these subscriptions has arisen in the past, and to facilitate the making up of accounts and reduce correspondence, Officers are requested to give their Bankers (whether Messrs. Cox & Co.,

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or other agents), the necessary authority to pay to the Band Fund in the month of April, if they have not already done so.

Officers not banking with the Army Agents should inform their bankers that the subscription, as claimed by Messrs. Cox & Co., should be remitted not later than the 30th April each year. Bankers receiving these instructions should be asked to inform Messrs. Cox & Co., that this authority has been received.

THE WORK OF THE ROYAL ENGINEERS IN THE EUROPEAN WAR, 1914–18.

THE volume on *Military Mining* is now on sale. Price, 12s. 6d. (to members, 7s. 6d.).

FOR SALE.

SUBS. COLONEL'S mess jacket and waistcoat (R.E. pattern converted). What offers?

Apply Brig.-General H. R. Stockley,
c/o Cox & Co.,
16, Charing Cross.

SCHOOL OF MILITARY ENGINEERING, CHATHAM.
WINTER SEASON—1922–23.

LECTURES (Second Series) to be delivered at the LECTURE THEATRE, S.M.E. Main Building. To commence at 1730 hours.

DATE.	LECTURER.	SUBJECT.
Thurs., Feb. 1st	Air Vice-Marshal Sir William G. H. Salmond, K.C.M.G., C.B., D.S.O.	The Policing of the Empire by the Royal Air Force.
,, ,, 8th	Brig.-General J. E. Edmonds, C.B., C.M.G., Historical Section (Military Branch) Committee of Imperial Defence.	Breaks-through.
,, ,, 15th	Lieut.-Colonel G. H. Addison, C.M.G., D.S.O., R.E. Instructor, Cambridge University.	Every-day Mathematics for Engineers.
,, ,, 22nd	Colonel H. L. Crosthwait, C.I.E. (late R.E.).	The Survey of India.
,, Mar. 1st	Colonel C. P. Heywood, C.M.G., D.S.O., *p.s.c.*, Deputy Director of Mil. Training, War Office.	Infantry Tactics in Attack and Defence.
,, ,, 8th	Major M. N. MacLeod, D.S.O., M.C., R.E. Chief Instructor, Artillery School, Larkhill.	The Use of Aeroplane Photographs for Map-making in the Field.
,, ,, 15th	Col.-Commandant W. H. Newcome, C.M.G., D.S.O., R.A., late Commandant, School of Artillery, Larkhill.	Artillery in close support of Infantry.
,, ,, 22nd	Major-General S. H. Sheppard, C.B., C.M.G., D.S.O., *p.s.c.*, late Major-General, Royal Engineers and Pioneers, Army Headquarters, India.	Military Engineering on Various Frontiers.

* Confidential.

Plain Clothes may be worn at all Lectures other than those marked Confidential. At Lectures marked Confidential, Uniform will be worn.

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THE

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TO THE

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SECRETARY, THE INSTITUTION OF ROYAL ENGINEERS CHATHAM.

Telephone CHATHAM, No. 669.

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THE ROYAL CHARTER.

THE Secretary has received the following letter from the Clerk of the Privy Council:—

19th February, 1923.

SIR,

With reference to the Petition lodged by you, praying for the grant of a Charter to the Institution of Royal Engineers, I have to state, for the information of the Promoters, that the King was pleased, at a Council held on the 29th ultimo, to approve the grant of the Charter prayed for.

The Order in Council approving the Draft has been issued to the Home Office, from which Department you will receive a communication in due course.

I am, Sir,

Your obedient servant,

(*Sd.*) ALMERIC FITZROY.

ANNUAL CORPS MEETING, ETC.

IT is notified for information that the following dates have been fixed for:—

R.A. *v.* R.E. Cricket Match at Lord's	Wednesday & Thursday, 13th & 14th June, 1923,
R.E. Reception	Thursday, 14th June, 1923.
Annual Corps Meeting	Friday, 15th June, 1923.
R.E. Corps Dinner	Friday, 15th June, 1923.

Further particulars will be published in April *Supplement*.

ANNUAL CORPS DINNER.

SUBJECT to the approval of the R.E. Dinner Committee, it is proposed at the next annual Corps Dinner to arrange one or more tables for officers, past and present, of the 3rd Royal Bombay Sappers and Miners.

All such officers, who intend to be present at the Dinner, are requested to notify Capt. R. S. Rait-Kerr, D.S.O., M.C., R.E., Drill Hall, Ashburnham Road, Bedford, or, in the case of officers at Cambridge, Lieut. P. F. Foley, R.E., Downing College, Cambridge.

Notice should be given at least fourteen days before the date fixed for the Dinner.

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ROLL OF HONOUR OF THE ARTISTS RIFLES.

A COPY of the Roll of Honour and War Record of the Artists Rifles has been presented to the officers of the Royal Engineers by Colonel H. A. R. May, C.B., V.D. (Late C.O. Artists Rifles).

It contains the names of 312 men of the Artists Rifles who received commissions in the Royal Engineers during the War, many of whom were subsequently killed in action or died of wounds.

This book has been placed in the S.M.E. Library, R.E. Headquarters Mess, Chatham.

D.C.M.'S IN THE GREAT WAR.

A COMPLETE collection of the published accounts of the actions for which the Distinguished Conduct Medal was allotted to those of the Royal Engineers who received it during the European War of 1914–18, has been presented by Colonel H. B. Jones C.B., to the Commandant S.M.E. A proposal has been made to publish the whole list as a series of supplements in *The Sapper*. The original collection, after it has been exhibited in some of the Serjeants' Messes, will eventually be deposited in the R.E. Museum.

HISTORY OF THE WAR.

BRIG.-GENERAL J. E. EDMONDS is now completing Volume II of the official History of the War, which deals with the period of October–December, 1914, and the fighting at Antwerp, La Bassée–Armentières–Ypres. The R.E. War Diaries for the period were very meagre, owing to the many successive days of fighting. He would be much obliged if officers who could furnish him with any account of R.E. work and deeds with which they were connected would do so. He has a good account of the counter-attack of the 5th Field Company on the 11th November, 1914.

NOTES ON THE EQUITATION COURSE AT WEEDON.

By Captain H. G. PYNE, M.C., R.E.

THE object of the course is to turn out an officer who is capable of instructing others in riding and horsemanship. With this end in view each officer is instructed in the latest theory and practice of the subject so that he can impart his knowledge in the best way and demonstrate practically what he wants done. The veterinary officer gives a series of lectures combined with practical work throughout the course. This includes knowledge of the skeleton, important muscles and ligaments, tendons and conformation generally. Shoeing, both from theoretical and practical standpoint, diseases, non-infectious and infectious, with special attention to those actually found in the service both in peace and war. A Board of Veterinary Officers from the War Office examines students at the end of the course and gives Veterinary certificates to successful candidates.

Roughly speaking, the course may be divided into two parts. The first part, about three-fifths of the total time, is spent in instructing the students; the second part, about two-fifths of the total, is spent in teaching the students how to instruct others.

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I will now endeavour to describe in detail how this is carried out.

On arrival at Weedon each officer is given a trained horse, a half-trained horse, which is usually a difficult horse to manage, and a raw, untrained remount. Total, three horses.

At first, until the leg muscles become well developed, students ride four hours a day only, the remainder of the time being spent on physical training, with the object of suppling the body, lunging and leading in hand remounts, grooming horses, with the object of teaching the correct way to do it, and what to look for in a badly groomed horse, dismounted sword drill, and lectures. Students are put through the recruits' course of riding on trained horses and the correct position in the saddle is obtained before any more advanced work begins.

After the first month physical training and practical grooming cease, the time thus spare being spent in riding and preliminary training of remounts. As soon as the remounts are fairly docile they are backed by students, and the process of training them into first-class officers' chargers is begun.

As soon as the students have acquired a firm seat independent of the reins, instruction in " hands " begins, first in the schools and then in the open. The method employed is to jump over all manner of obstacles, placed chiefly in awkward places, such as into and out of narrow lanes, at the top or bottom of steep slopes, etc. During this time mounted sword drill is practised from a ceremonial point of view only.

When hands and seat are fairly correct, the higher forms of Equitation are introduced, such as balancing and collecting a horse at the more extended paces, changing leading leg at canter, presenting a horse at an obstacle in the correct way and timing him so that he will make his spring the correct distance from the obstacle. The more advanced School figures, and bending at trot and canter, are introduced.

The education of half-trained horses and remounts progresses during this period, the remounts being jumped over several of the simple obstacles.

During this period lectures are given on all the subjects dealt with, such as stable management, training the young horse, bits and bitting, balance, collection, timing fences, psychology of the horse, etc., etc. This may be said to end the first period and, though a certain amount of instruction goes on till the very end, the main object from this on is to teach students how to instruct others.

With this object in view, each student is placed in charge of the work for a day. He has to decide what to do, how to do it, and do all the criticism for that day. He also has to deliver a lecture, on some subject given by the instructor, to the remainder of the class. At the end of the day the Instructor or Chief Instructor criticizes the day's work and points out the faults of the would-be instructor.

Some of the more important lessons for the recruit, such as the trotting lesson, cantering lesson, first jumping lesson, etc., are drawn up in the manner which has been found most suitable and have to be given in this way; other minor lessons are left to the discretion of the student.

The work continues up to the end of the course, when examinations

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take place. Students are examined in riding, training of their remounts, instruction work and general knowledge. The latter is done by a written paper.

From my own personal point of view, I consider the course excellent in every way and I have no criticisms to offer. To anyone who is fond of horses and riding, and who does not mind seven months of very hard work, I thoroughly recommend the course. As to what one learns there, I can only say that, in spite of the fact that I have been riding and looking after horses for the last twenty years, I have learnt more in the last seven months than in all the previous time.

Aldershot. 17–12–22.

Football.

RUGBY.

The Corps match versus R.N.C. Greenwich, which should have been played on January 24th will be played on March 21st at Greenwich.

RUGBY FIXTURE LIST.

FIRST XV.

DATE.	OPPONENTS.	GROUND.	RESULT.
1923.			
Sat., Mar. 3rd ...	Old Whitgiftians	Chatham	
Sat., ,, 10th ...	Old Emanuels	Chatham	
Wed., ,, 14th ...	Royal Naval College	Greenwich	
Sat., ,, 17th ...	Old Merchant Taylors	London	
Wed., ,, 21st ...	**R.E. v. R.N.C.**	Greenwich	
Sat., ,, 24th ...	Edgware	Chatham	
Wed., ,, 28th ...	Blackheath	Blackheath ...	
Sat., ,, 31st ...	London Irish	Norbiton	

"A" UNITED SERVICES XV.

DATE.	OPPONENTS.	GROUND.	RESULT.
1923.			
Wed., Mar. 7th ...	St. Mary's Hospital	Chatham	
Sat., ,, 10th ...	Hon. Artillery Co.	Chatham	
Sat., ,, 17th ...	Dartford	Chatham	
Sat., ,, 24th ...	St. Mary's Hospital	London	

Corps Fixtures are shown in black type.

G. D. DE'ATH, *Capt., R.E., Hon. Secretary.*

R.E. OFFICERS' ASSOCIATION FOOTBALL CLUB.

OWING to adverse weather conditions and consequent bad state of grounds, only two matches have been played, but in both of these we were successful.

27th January, v. Army Crusaders, played on the U.S. ground, resulting in a victory for the Sappers by 3 goals to 1. The whole side played extremely well and the victory was well deserved. This result was particularly gratifying as several army players were playing for the Crusaders.

It is hardly possible to comment on individual play, but Steedman, Blagden and Masters were the pick of an excellent side. Sergeant Farrigan and Sapper G. Wood are to be thanked for this very able support as substitutes.

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Old Lancing Boys.—Played on 3rd February, resulting in a victory of 3—0 for the Sappers. A somewhat scrappy game, caused by a strong side wind and chiefly noteworthy for the number of chances missed by the Sappers. Apart from the above drawbacks, however, it was a cheery game against a very pleasant side—one which is to be repeated in the near future.

Hockey.

FIXTURE LIST.

DATE. 1923.	CLUB.	GROUND.	RESULT
Sat., Mar. 3rd ...	Bromley	Bromley	
Wed., ,, 7th ...			
Sat., ,, 10th ...	Staff College	Chatham	
Wed., ,, 14th ...	St. Thomas's Hospital	Away	
Sat., ,, 17th ...	Southgate	Chatham	
Wed., ,, 21st ...	R.N.C., Greenwich	Chatham	
Sat., ,, 24th ...			

PERSONAL NOTES.

COLONEL H. ST. J. L. WINTERBOTHAM, C.M.G., D.S.O., has been nominated as the representative of the Institution of Royal Engineers on the General Council of Honour in connection with the forthcoming International Air Congress, to be held in London from 25th to 30th June, 1923.

MAJOR E. D. CARDEN, O.B.E., R.E., will represent the Institution of R.E. at the Congress of The Royal Sanitary Institute at Hull, July 30th to August 4th, 1923.

Problems.

PROBLEM No. 58. (Solution by Colonel Arthur Hill, late R.E.).

Four men in succession toss a sovereign on condition that the first who throws "heads" keeps the coin. Show that the chance of the first who tosses is worth 10/8 and that of the last 1/4.

Let A, B, C and D represent the four men.

Then A's chance of a head at first toss $= \frac{1}{2}$
His chance of failing and letting B $= \frac{1}{2}$
Hence B's chance of a head $= \frac{1}{2} \times \frac{1}{2}$ $= \frac{1}{4}$
Chance of A and B both failing to get a head $= \frac{1}{4}$
Therefore C's chance of a head $= \frac{1}{2} \times \frac{1}{4}$ $= \frac{1}{8}$
Chance of A, B and C all failing $= \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2}$ $= \frac{1}{8}$
Hence D's chance of a head $= \frac{1}{2} \times \frac{1}{8}$ $= \frac{1}{16}$
Also chance of A, B, C and D all failing $= \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} = \frac{1}{16}$
Therefore A's chance on his second toss $= \frac{1}{2} \times \frac{1}{16} = \frac{1}{32}$

And A s total chance is the sum of a geometrical series to infinity—where first term is $\frac{1}{2}$ and common ratio is $\frac{1}{16}$, and this is $\frac{\frac{1}{2}}{1 - \frac{1}{16}} = \frac{8}{15}$.

Therefore the money value of his chance is $\frac{8}{15}$ of £1 = 10s. 8d.

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Extending a similar calculation, it will be found that D's second chance of a head $= \frac{1}{2^5 6}$ and therefore his total chance is the sum of series $\frac{1}{1^5 6} \cdot \frac{1}{2^5 6}$, etc., to infinity $= \frac{\frac{1}{1^5 6}}{1 - \frac{1}{1^5 6}} = \frac{1}{1^5}$,

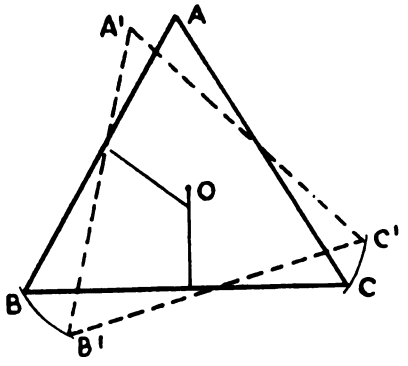
and the worth of this expectation is $\frac{1}{1^5}$ of £1 = 1s. 4d.

Q.E.D.

In the further calculation on the same lines as the above, it will also appear that B's total chance of being the first to throw a head is $\frac{4}{1^5}$, and the money value of his chance is $\frac{4}{1^5}$ of £1 = 5s. 4d., while C's total chance is $\frac{2}{1^5}$ with a money value of 2s. 8d. The total of the above four money values is £1, as of course it should be.

PROBLEM 65. (Solution.)

A heavy equilateral triangle, weight W, side a, is suspended in equilibrium in a horizontal position by three vertical weightless cords each of length (l) which are attached to a ceiling. A couple of moment M is applied to the triangle in its plane. Find how high it will rise. ABC and A'B'C' are the original and displaced positions of the Δ, both having by symmetry a common vertical axis passing through O, the circum centre of ABC. Let A"B"C" (not drawn) be the projections of ABC in the plan of A'B'C'. Let $\angle$ AOA' = BOB' = COC' = θ. Let ϕ be inclination of the strings at A', etc., to the vertical. Let z be height ABC rises.



Then by principle of virtual work

Wdz = (work done by couple in turning through $d\theta$) = M$d\theta$ .....(1)

$$\sin \phi = A'A''/l = 2\ OA \sin \frac{\theta}{2} \Big/ l = \frac{2a}{\sqrt{3}} \sin \frac{\theta}{2} \Big/ l \quad \text{.....(2)}$$

Differentiation of (2) gives $l \cos \phi \frac{d\phi}{d\theta} = \frac{a}{\sqrt{3}} \cos \frac{\theta}{2}$ .....(3)

also $z = l\ (1 - \cos \phi)$ .....(4)

$\therefore$ $\frac{dz}{d\phi} = l \sin \phi$ .....(5)

Elimination of $\frac{dz}{d\phi}$ between (1), (3), (5), gives

$$\frac{M}{W l \sin \phi} = \frac{a}{\sqrt{3}\ l \cos \frac{\theta}{2} \cos \phi} \quad \text{.....(6)}$$

Elimination of $\frac{\theta}{2}$ between (2) and (6) gives

$$\frac{a^2\ W^2 \tan^2 \phi}{3\ M^2} + \frac{3\ l^2 \sin^2 \phi}{4\ a^2} = 1 \quad \text{.....(7)}$$

which is a quadratic in $\cos^2 \phi$.

and z is given by $z = l\ (1 - \cos \phi)$.

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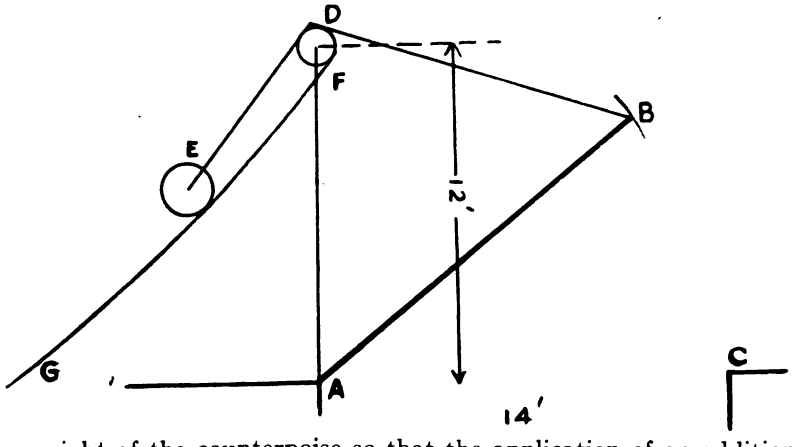
The data given lead to complicated radicals, but by properly choosing M and l in terms of W and a, it is possible to frame a question in which radicals will not appear.

Correct solutions have been received as under :—

Problems 65 and 66.—Major G. Nottidge, O.B.E.

PROBLEM 67.

A DRAWBRIDGE, 14 ft. length, weight 1 ton, is pivoted at one end A, and is raised by a light wire rope passing over a pulley of 12-in. diameter, 12 ft. vertically above A ; the other end of the wire rope is attached to a rolling counterpoise E, 2-ft. diameter, rolling on a curve FG. Determine graphically or in any way the shape of the curve FG and



the weight of the counterpoise so that the application of an additional pull not exceeding 300 lbs. applied at E may be sufficient to raise the bridge in any position. Any reasonable assumptions as to friction may be made. (*Note.*—The drawbridges of Forts Delhi, Agra and Allahabad are designed according to this pattern, but owing to faulty shape of the curve FG and too light a counterpoise, a tackle with about 10 men pulling is required for raising.)

PROBLEM 68.

A and B play golf, and at each hole it is equally probable that the hole may be won by A, won by B, or halved. Find A's chance of winning, halving or losing the match if he is (1) 2 up and 3 to play ; (2) 2 up and 4 to play ; (3) m up and $m+n$ to play.

J. M. WADE, *Lieut.-Colonel.*

Births.

KANE.—On the 7th February, 1923, at Cairo, Egypt, to FLORENCE LOUISE, wife of Capt. C. J. KANE, R.E., a son.

LOCH.—At Maymyo, Burma, on the 21st January, 1923, the wife of Major G. C. B. LOCH, Royal Engineers, A.D.M.W., Army Headquarters, India, a son.

MARTIN.—On the 17th February, at Poolmerick, Cobham, Kent, to Mab. (*ée* Hingston) wife of Capt. C. G. Martin, V.C., D.S.O., R.E., attached Egyptian Army, a son.

MAURICE.—On the 10th February, at P.O. Muden, Natal, the wife of Lt.-Col. L. C. MAURICE, O.B.E., late R.E., of a son.

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MICHELLI.—On February 9th, at Brooklyn Lodge, Sevenoaks, to PIETRO and FLORENCE MICHELLI, the gift of a second son.

ROOME.—On the 8th February, at Mussoorie, U.P., India, the wife of Capt. H. E. ROOME, M.C., R.E., of a son.

Marriages.

BAKER-CARR—DICKINSON.—On the 12th February, at St. Peter's, Cranley Gardens, Major H. B. F. BAKER-CARR, late Argyll and Sutherland Highlanders, to RACHEL MARY, youngest daughter of the late Colonel DICKINSON, R.E., and of Mrs. DICKINSON.

BEHRENS—CAMPBELL.—On the 27th January, 1923, at St. John's Church, Mentone, Lt.-Col. T. T. BEHRENS, R.E., to MARY STEWART, only daughter of the late P. W. CAMPBELL (WRITER TO THE SIGNET), and of Mrs. CAMPBELL, of 25 Moray Place, Edinburgh.

BUTLER—DEPLEDGE.—On the 23rd December, 1922, at Vernon, B.C., WILFRID JOHN BUTLER, son of the late Col. G. J. BUTLER, R.E., and of Mrs. BUTLER, 82 Belgrave Road, S.W., to GLADYS, daughter of the late BRADLEY DEPLEDGE, and Mrs. A. C. CLARK, of Clifton, Bristol.

LAFFAN—SMITH.—On the 10th February, at St. Mary's-the-Lees, Cambridge, by Rev. Fr. Vernon, S.D.C., assisted by Rev. G. H. Clayton, Rev. ROBERT GEORGE DALRYMPLE LAFFAN, Fellow of Queen's College, Cambridge, son of Mrs. E. S. LAFFAN and the late E. S. LAFFAN, I.C.S., and grandson of the late General Sir ROBERT LAFFAN, K.C.M.G., R.E., to KATHERINE, widow of T. RIDSDILL SMITH, youngest daughter of the late G. F. BINDLOSS.

LATHAM—TURNER.—On 3rd January, at Port-of-Spain, Trinidad, Capt. GEORGE HILTON LATHAM, R.E., elder son of A. M. LATHAM and Mrs. LATHAM, of 7 Cheyne Gardens, Chelsea, London, to MYRA HILDA TOM, widow of EDWIN SYERS TURNER, Lieut. R.N.V.R., and grand-daughter of Madame DE BOSSIÈRE, of Champs Elysées, Maraval, Trinidad.

PENNY—BACCHUS.—On the 1st February, at St. Mark's, Bangalore, by the Rev. E. Brownrigg, O.B.E., BRYAN DE Q. PENNY, third son of the late Maj.-Gen. C. B. F. PENNY, R.E., and Mrs. PENNY, Highcliff, Weymouth, to HELEN MAUD, fourth daughter of the late JOHN BACCHUS, Oak Mount, Bradford, and Mrs. BACCHUS, Grassington.

Deaths.

CROWTHER.—On the 7th Feb., at the Royal Naval Hospital, Chatham, the result of a motor accident, CHARLES TILLARD BENDYSHE CROWTHER, R.E., aged 24.

INGLIS.—At 2, Staunton Lodge, Gosport, on the 18th January, JEAN VIOLET, baby daughter of Major and Mrs. INGLIS, aged 18 months.

MAINGUY.—On 9th February, 1923, at Les Roquettes, Guernsey, FRANCES MATHILDA, widow of Maj.-Gen. F. B. MAINGUY, aged 77.

OLDHAM.—On 4th February, at 11, Albany Villas, Hove FRANCIS GEORGE OLDHAM, Col., late Royal Engineers, eldest surviving son of the Revd. JAMES OLDHAM, in his 84th year.

SEBAG-MONTEFIORE.—On 9th February, CECIL SEBAG-MONTEFIORE, of 37, Rosary Gardens, S.W., aged 48.

WOOD.—On the 12th February, at Bodenham, Herefordshire, after a short illness, Colonel C. K. WOOD, O.B.E., retired R.E., only remaining brother of Maj.-Gen. Sir Elliott Wood, K.C.B., Colonel-Commandant, R.E. aged 71.

Corps News.

Appointments Approved.

Captain and Brevet Major H. B. W. Hughes, D.S.O., O.B.E., to be Adjutant, 1st Divisional Engineers, Aldershot.

Captain and Brevet Major E. E. Calthrop, M.C., to be Adjutant, 2nd Divisional Engineers, Aldershot.

Captain A. P. A. Lewis to be Adjutant, 3rd Divisional Engineers, Bulford.

Lieut. W. A. Maidment, Coast Battalion, to be Adjutant, Kent Fortress, R.E. (T.A.), Gillingham.

Lieut. W. G. Irvine-Fortescue, M.C., to be Adjutant, 51st Highland Divisional Engineers (T.A.)

Lieut. B. E. C. Dixon, M.C., to be Adjutant, 53rd Welsh Divisional Engineers (T.A.).

Lieut.-Colonel R. J. Done, D.S.O., to be Commanding Royal Engineer, North Aldershot District, and 2nd Division.

Lieut.-Colonel E. G. Wace, C.B., D.S.O., to be Commanding Royal Engineer, Camps and Roads District, Aldershot.

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Movements at Home.

Major B. H. Wilbraham, D.S.O., from Hounslow to Aldershot.
Lieut. and Qrmr. C. S. Sykes, from Beaumaris to Oxford.
Captain and Qrmr. F. J. White, from Preston to Woolwich.
Captain and Qrmr. G. Cox, M.B.E., from Shrewsbury to War Office.
Lieut. and Qrmr. E. Bright, from Chatham to Longmoor.
Lieut. and Qrmr. D. Miller, from Chatham to Shrewsbury.
Lieut. and Qrmr. F. W. Roberts, from Hertford to York.
Lieut. W. A. Maidment, Coast Battalion, from Greenock to Gillingham.
Major H. P. Jesson, from Gillingham to Sheerness.
Brevet Major J. W. J. Raikes, from Half-pay to Longmoor.
Major W. P. Craig, Coast Battalion, from Sheerness to Pembroke Dock.
Lieut. W. G. R. Nutt, M.C., from Norwich to Aldershot.

Arrivals Home.

From Constantinople.—Lieut.-Colonel C. B. O. Symons, C.M.G., D.S.O., on leave pending taking up appointment under Air Ministry in Iraq.

From India.—Lieut.-Colonel A. H. D. Riach, on leave of absence pending retirement. Captain A. H. B. Papillon, on leave of absence pending reversion to the British Establishment. Captain A. C. McIntosh, M.C., on leave of absence.

From Sierra Leone.—Major J. S. Bisset and Lieut. F. D. Mann, on completion of tour of service and to R.E. Depôt, Chatham.

Embarkations.

For India.—Lieut.-Colonel G. J. P. Goodwin, D.S.O., Bt. Major J. H. Stafford, M.C., Captain F. I. de la P. Garforth, and Lieuts. H. F. T. Aldous and A. Bennetts, for a tour of service.

For Malta.—Colonel R. A. Gillam, C.M.G., D.S.O., to take up appointment of Chief Engineer.

Reversion to the British Establishment.

Captain A. H. B. Papillon, with effect from 21st May, 1923.

LEVEES AND INVESTITURES.

Orders and Decorations to be Worn with Service Dress.

The King has been pleased, as a purely temporary measure, to approve of orders, decorations and medals being worn with service dress at Levees and Investitures.

Broad ribands (Knights Grand Cross and Knights Grand Commanders) will not be worn with service dress.

Stars of Orders.—Stars not exceeding two in number will be worn on the left side, in line, and immediately below the medals.

Badges of Orders Worn Round the Neck.—Not more than two such badges will be worn. An officer in possession of one badge will wear it round the neck with the riband under the shirt collar and the badge over the tie; an officer in possession of more than one badge will wear the badge of the senior order as above described, and that of the next senior order suspended from a riband emerging about ¾ in. immediately below the top buttonhole of the jacket, a small eye being stitched inside the coat to which the riband is fastened by a hook.

Other Orders, Decorations and Medals.—To be worn in the prescribed order on the left breast. In cases where a decoration or medal has been awarded but not issued, the riband will be worn in the place assigned to the decoration or medal.

No alterations will be made in existing regulations in respect of the wearing of orders, decorations and medals by officers who attend Levees and Investitures in full dress uniform.

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ARMY INSTRUCTIONS (INDIA).

No. 155 of 1920.

DELHI, *9th March*, 1920.

155.—CONCESSION OF ACCUMULATING PRIVILEGE LEAVE IN ACCORDANCE WITH FINANCE DEPARTMENT LETTER NO. 168-C.S.R., DATED 24TH FEBRUARY, 1919 (ARMY INSTRUCTION (INDIA) NO. 332 OF 1919), TO ROYAL ENGINEER OFFICERS AND OFFICERS OF THE INDIAN MEDICAL SERVICE AND INDIAN MEDICAL DEPARTMENT WHO WERE SUBJECT TO THE CIVIL LEAVE RULES PRIOR TO THE WAR AND WERE RECALLED TO MILITARY DUTY DURING HOSTILITIES.

Government of India, Finance Department, Letter No. 1447-C.S.R., dated the 15th December 1919.

It is notified that the concession of accumulating privilege leave which was granted to civil officers in Finance Department letter No. 168-C.S.R., dated the 24th February, 1919 (re-published as Army Instruction (India) No. 332 of 1919), is hereby extended to Royal Engineer officers and officers of the Indian Medical Service and Indian Medical Department who were subject to the civil leave rules prior to the war and were recalled to military duty during hostilities.

2. The leave of these officers while actually rendering military service is regulated under the military leave rules, but the Government of India have decided that they shall be eligible for the above concession on exactly the same conditions as officers of the ordinary civil services who went on military duty but remained subject to the civil leave rules.

3. Accordingly Royal Engineer and Medical officers who wish to avail themselves of the accumulation concession will for this purpose, and for this purpose only, count their military service as qualifying for privilege leave under the civil rules, and all war leave taken on full pay, other than casual leave or special leave for officers wounded or invalided, will be counted as privilege leave taken.

The balance in favour of, or against, the officer will then be added to, or deducted from, the amount of privilege leave at the officer's credit when he reverted to military duty.

No. 36 of 1923.

9th January, 1923.

36.—LEAVE CONCESSIONS TO OFFICERS OF THE ROYAL ENGINEERS AND INDIAN MEDICAL SERVICE WHO HAVE BEEN DEBARRED UNDER THE TERMS OF INDIA ARMY ORDER NO. 452 OF 1917 FROM ENJOYING LEAVE EARNED IN CIVIL EMPLOY.

It has been decided, with the approval of the Right Hon'ble the Secretary of State for India, that Royal Engineers and Indian Medical Service officers who, owing to retirement, etc., have definitely been prevented from returning to civil employ and thus lose all claim to civil leave which they had earned and to which they would have been entitled under Army Instruction (India) No. 155 of 1920, had they not been debarred from returning to civil employment, shall be permitted

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to avail themselves of the more favourable of the following alternative leave concessions, subject to a maximum period of two years' leave :—

(*A*) (*i*) The concession of accumulating privilege leave on exactly the same conditions as are prescribed in Army Instruction (India) No. 155 of 1920 for Royal Engineers and Indian Medical Service officers who return to civil employ, and

(*ii*) Furlough to the extent of civil furlough earned before reversion to military duty.

(*B*) (*i*) Sixty days' special war leave under the conditions laid down in Army Instruction (India) No. 106 of 1920, together with such accumulated privilege leave as has been earned by them under military rules while in military employment, and

(*ii*) Military furlough earned under military rules.

2. The above decision will have retrospective effect to cover outstanding cases.

3. No officiating allowances will be admissible during privilege leave.

4. The expenditure involved in respect of leave and furlough earned in civil employ is chargeable to civil estimates.

ARMY PAY.

A NEW Royal Warrant provides that past or future service rendered in "quasi-military employment" (Pay Warrant Article 92), that is, an appointment which, in the opinion of the Army Council, is clearly of a nature to afford practical experience likely to be afterwards of advantage in military service, shall reckon for increase of pay with effect from 1st December, 1922.

THE BRITANNIA TROPHY—NAVY'S GIFT TO THE ARMY.

IT is announced in an Army Order that the Lords Commissioners of the Admiralty, on behalf of the officers and men of the Royal Navy and Royal Marines, have presented to the Army Council a trophy for team competition with the service rifle for teams from the Regular Army.

The trophy consists of a silver replica of the Nelson Column, 3 ft. 6 in. in height, on an oak base. It has been designated "The Britannia Trophy."

The Army Rifle Association is charged with the custody of the trophy, the drawing up of the conditions of the competition, and the conduct of the competition.

The first competition will be held during the Bisley Meeting of the Army Rifle Association in 1923.

Extracts from the London Gazette.

CORPS OF ROYAL ENGINEERS.—Maj.-Gen. H. W. Duperier, ret. pay, is appointed Col.-Commdt., *vice* Gen. W. P. Tomkins, C.I.E., Unempld. Supern. List, Ind. Army (decd.) 20th Nov. 1922. Lt.-Gen. Sir Henry M. Lawson, K.C.B., ret. pay, is appointed Col.-Comdt., *vice* Lt.-Gen. G. Henry, C.B., ret. pay (decd.) 20th Nov. 1922. Maj. W. F. Mathews is placed on the h.p. list on account of ill-health 6th Jan. Following Capts. to be Majs. :—Bt. Maj. O. E. Wynne, O.B.E., 13th Dec. 1922. P. W. Bliss, 21st Dec. 1922.

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ESTABLISHMENTS.—SCHOOL OF MILITARY ENGINEERING.—*Asst. Instr. in Fortifications.*—Capt. J. T. Heath, D.S.O., M.C., *vice* Capt. J. E. Chippindall, M.C., 2nd Dec. 1922.

MEMORANDA.—The following to be Colonels, 6th Jan.:—With seniority 3rd June 1919:—Lt.-Col. and Bt. Col. J. W. S. Sewell, C.M.G., h.p. list, Lt.-Col. and Bt. Col. E. N. Stockley, D.S.O., h.p. list. With seniority 1st Jan. 1922:—Maj. and Bt. Lt.-Col. A. S. Redman, C.B. Lt.-Col. N. J. Hopkins, h.p. list, retires on ret. pay, 4th Jan. Maj. W. F. Mathews, h.p. list, is restd. to full pay whilst empld. with the R.E. 6th Jan. Lt. J. Adcock, relinquishes T/rank of Capt. 1st Jan. 1922. (5-1-22.)

CORPS OF ROYAL ENGINEERS.—The notification in the *Gazette* of 12th Dec. 1922, regarding Capt. and Bt. Maj. J. D. Gemmill, M.C., is cancelled.

ESTABLISHMENTS.—TANK CORPS.—*To be Engr. Officer* (*Cl. GG*).—Lt. D. M. F. Sheryer, R.E. and Tank Corps, 8th June 1922.

TERRITORIAL ARMY.—48th (*S. Mid.*) *Divl. Engrs.*—Maj. O. S. Davies, D.S.O., to be Lt.-Col. 1st Dec. 1922. 55*th* (*W. Lancs.*) *Divl. Engrs.*—Lt. S. E. Bold ceases to hold a commn. in the T.A. for failing to attend the Annual Training in Camp. 10th Jan.

MEMORANDA.—Col. R. F. Edwards, C.M.G., retires on ret. pay, 10th Jan., and is granted hon. rank of Br.-Gen. Lt.-Col. F. P. Rundle, C.M.G., D.S.O., h.p. list, retires on an Indian Pension, 10th Jan., and is granted rank of Col. (9-1-23.)

CORPS OF ROYAL ENGINEERS.—Following Majs. to be Lt.-Cols.:—P. B. O'Connor 14th Nov. 1922, Bt. Lt.-Col. E. M. S. Charles, C.M.G., D.S.O., 31st Dec. 1922. Following Lts. to be Capts.:—N. C. D. Brownjohn, M.C., 29th Nov. 1922. N. A. Coxwell-Rogers, 30th Nov. 1922. H. F. Lucas, 13th Dec. 1922. E. N. Clifton, 20th Dec. 1922. R. F. O'D. Gage, M.C., 21st Dec. 1922. R. M. H. Lewis, M.C. 30th Dec. 1922.

TERRITORIAL ARMY.—46*th* (*N. Mid.*) *Divl. Engrs.*—2nd Lt. H. R. Werner, late Tank Corps, to be 2nd Lt. 9th Dec. 1922. 54*th* (*E. Angl.*) *Divl. Engrs.*—Maj. G. C. Walker, O.B.E., M.C., T.D., resigns commn., 13th Jan., and retains rank, with permission to wear the prescribed uniform.

MEMORANDUM.—Lt.-Col. and Bt. Lt.-Col. R. A. Gillam, C.M.G., D.S.O., h.p. list, to be Col., 6th Jan., with seniority 3rd June 1919. (12-1-23.)

COMMANDS AND STAFF.—T/appt. made at War Office:—*Staff Capt.*—Bt. Maj. Æ. F. Q. Perkins, M.C. 1st Jan.

Following relinquishes T/appt.:—*Dep. Dir. of Works.*—Maj. (now Bt. Lt.-Col.) D. K. Edgar, D.S.O., and relinquishes T/rank of Col. 9th Apr. 1919.

CORPS OF ROYAL ENGINEERS.—Lt.-Col. D. Ogilvie, C.I.E., retires on an Indian Pension, 13th Dec. 1921. (Substituted for notification of 27th Feb. 1922.)

ROYAL CORPS OF SIGNALS.—Following Lts., from R.E., to be Lts. 17th Jan., with seniority 6th Dec. 1918, and precedence next above R. H. Nisbet:—E. S. Heffer, G. S. O'N. Power, F. C. Curtis. Lt. T. A. R. Scott, from R.E., to be Lt., 17th Jan., with seniority 25th July 1919.

REGULAR ARMY RESERVE OF OFFICERS.—Lt.-Col. W. R. Izat, D.S.O., ret., Ind. Pension, to be Lt.-Col. 31st Dec. 1922, with seniority 16th Jan. 1921. The notification in the *Gazette* of 22nd Dec. 1922, regarding Lt.-Col. J. D. Gemmill, M.C., is cancelled.

CORPS OF ROYAL ENGINEERS.—The commn. of 2nd Lt. A. J. L. Whyte is antedated for purposes of seniority only, 15th Dec. 1919.

TERRITORIAL ARMY.—*Engineer and Railway Staff Corps.*—Lt.-Col. D. Cooper resigns commn., 2nd Jan., and retains rank, with permission to wear the prescribed uniform. Maj. W. A. Paterson, resigns commn., 2nd Jan., and retains his rank, with permission to wear the prescribed uniform.

MEMORANDA.—Following to be Cols.:—Lt.-Col. and Bt. Col. R. A. Gillam, C.M.G., D.S.O., h.p. list, 6th Jan., with seniority 3rd June 1919. (Substituted for notification of 12th Jan.). Lt.-Col. and Bt. Col. A. B. Carey, C.M.G., D.S.O., h.p. list, 17th Jan. with seniority 3rd June 1920. (16-1-23.)

Following relinquishes his T/appt.:—*G.S.O., 2nd Grade.*—Capt. R. Briggs, D.S.O., M.C., 18th Dec. 1922.

CORPS OF ROYAL ENGINEERS.—Following Capts. to be Majs.:—Bt. Maj. G. B. O. Taylor, C.B.E., 31st Dec. 1922, G. C. Gowlland, H. de C. Toogood, 6th Jan.

MEMORANDUM.—Lt. J. A. Scrutton, M.C., Spec. Res., and T/Capt. Tank Corps (now Capt., North'd Fus.) relinquishes appt. of Adjt. Tank Corps, 5th Aug. 1920. (Substituted for notification under "Tank Corps" in *Gazette* of 12th Nov. 1920). (10-1-23.)

Following appt. made at War Office:—*Staff Capt.*—Capt. F. J. H. Waller, vice Capt. T. H. Foster. 1st Jan.

CORPS OF ROYAL ENGINEERS.—The promotion of the following Majs. to the rank of Lt.-Col. is antedated as follows:—To 13th Dec. 1921:—Bt. Lt.-Col. (now Col.) C. O. Place, C.M.G., D.S.O., Bt. Lt.-Col. F. R. H. Eustace, D.S.O. Bt. Lt.-Col. P. K. Betty, C.M.G., D.S.O., to 19th Dec. 1921. To 31st Dec. 1921:—Bt. Lt.-Col. J. E. E. Craster, O.B.E., A. S. Holme, C.B.E., G. H. Willis, C.I.E., M.V.O. Bt. Lt.-Col. G. H.

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Addison, C.M.G., D.S.O., to 19th Jan. 1922. Bt. Lt.-Col. F. W. Robertson, O.B.E., to 1st Feb. 1922. Bt. Lt.-Col. H. de L. Pollard-Lowsley, C.M.G., C.I.E., D.S.O., to 10th Feb. 1922. Capt. R. L. Bond, D.S.O., M.C., to be Adjt., vice Capt. & Bt. Maj. J. H. Stafford, M.C. 4th Jan.

SCHOOL OF MILITARY ENGINEERING.—*To be Instr. in Construction.* (*Cl. CC*)—Capt. A. G. B. Buchanan, vice Capt. A. F. Day, 22nd Jan.

REGULAR ARMY RESERVE OF OFFICERS.—Lt.-Col. F. H. Kisch, C B.E., D.S.O., ret. pay, to be Lt.-Col., 29th Nov. 1922, with seniority 3rd Sept. 1918. Capt. R. G. M. Wilson, M.C., late R.E. to be Capt., 30th Dec. 1922, with seniority 1st Jan. 1922.

TERRITORIAL ARMY.—*50th (North'n) Divl. Engrs.*—Capt. E. J. Hoyle, O.B.E., to be Bt. Maj. 24th Jan. *London. Sig. Cos.* (*A.T.*)—Hon. Col. A. Bain, T.D., (Hon. Col., ret., T.F.) relinquishes appt. of Hon. Col. on completion of tenure, and retains his rank, with permission to wear the prescribed uniform. 24th Jan. *11th A.A.Bn.*—Capt. B. W. Holman, O.B.E., from Genl. List, T.A., to be Capt. 1st Jan., (23-1-23.)

Following T/appt. made:—*Staff Officer to Chief Engineer.*—(*Cl. CC*).—Capt. H. E. Biggs. 23rd Sept. 1922.

ROYAL CORPS OF SIGNALS.—Capt. R. Elsdale, M.C., from R.E., to be Capt. 20th Dec. 1922, with seniority 26th June 1917, and precedence next above G. E. Mansergh, M.C. (Substituted for notification of 22nd Dec. 1922.)

ESTABLISHMENTS.—SCHOOL OF MILITARY ENGINEERING.—*To be Chief Instr. in Workshops* (*Cl.Y.*)—Maj. G. C. Gowlland, vice Bt. Maj. H. H. Bateman, D.S.O., M.C., who relinquishes T/rank of Maj. 10th Jan.

TERRITORIAL ARMY.—*10th Anti-Aircraft Bn.*—Harry Eden Barrett (late Cadet, Winchester Coll. Contgt). Jun. Div., O.T.C., to be 2nd Lt. 27th Jan.

R.E. BALL, CHATHAM.

A BALL will take place in the Headquarter Mess on Thursday, 7th June, at 9.30 p.m. Officers who wish to invite friends are requested to send in their names, and names and addresses of their friends, to the Mess Secretary during May. Officers not stationed in the Thames and Medway Area, availing themselves of R.E. Mess Rule 26, are also requested to give notice in writing to the Mess Secretary during May.

Private Guests.—Each Subscriber to pay for his private guests as follows:—

Gentlemen	...	...	...	£1 7s. 6d. a head.
Ladies ...	...	...	...	15s. 0d. a head.

Extract from Rules, R.E. Mess, Chatham.

(Rule 24. Any Officer of the Corps or Special Honorary Member, under Rule 3b, can become a subscriber to such an entertainment. None but subscribers can invite friends.

Rule 25. Subscribers inviting guests cannot invite more than two ladies in excess of the number of gentlemen invited by them. Married officers, whose wives attend as public guests, cannot invite more than one lady in excess of the number of gentlemen invited by them, except in the case of a subscriber, who may ask his two daughters as well as his wife.

In case of invitations applied for within three weeks of the date of the dance, the Committee are empowered at their discretion to request the subscriber to reduce the number of ladies in his party, so that the ladies do not outnumber the gentlemen, the subscriber being considered one of the party.

Rule 26. No Member of the Mess in the Thames and Medway Area can be present at such an entertainment without being a subscriber. Members of the Mess, not stationed in the Thames and Medway Area, and their wives and children, may attend on payment of £1 each, or may be invited by a subscriber as his guest at the same charges as other private guests.

Members of the Mess not stationed in the Thames and Medway Area, inviting more than two ladies, must become subscribers to the Dance.)

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Dress.—Mess dress for officers in possession of this dress. Field Service Dress jacket and trousers (with "Sam Browne" belt) for officers not in possession of mess dress.

Miniature decorations and medals will be worn by officers and others attending in plain clothes.

LADIES' LUNCH.

There will be a Ladies' Lunch in the Mess the day after the Dance, from 1.15 to 2.30 p.m. Officers should inform the Mess Secretary by the 5th June, if they will be present, and number of guests they will have. The Lunch is for guests from a distance, and not for residents in Chatham and neighbourhood. The charge will be approximately 4s. a head.

Notices.

R.E. BAND CONCERTS.

R.E. BAND CONCERTS will be held in the R.E. Theatre, Brompton Barracks, from 3 p.m. to 4.30 p.m. on the following dates:—1923: March 6th, 20th, 27th.

R.E. BAND SUBSCRIPTIONS.

OFFICERS are reminded that the Annual Subscriptions of two days' pay falls due in April of each year.

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R.E. JOURNAL.

THE Secretary, Institution of Royal Engineers, would be grateful for any copies of the following *R.E. Journals* from any officers who may no longer require them:—July, 1918; February, 1920; June, 1922; October, 1922. These are required to complete sets.

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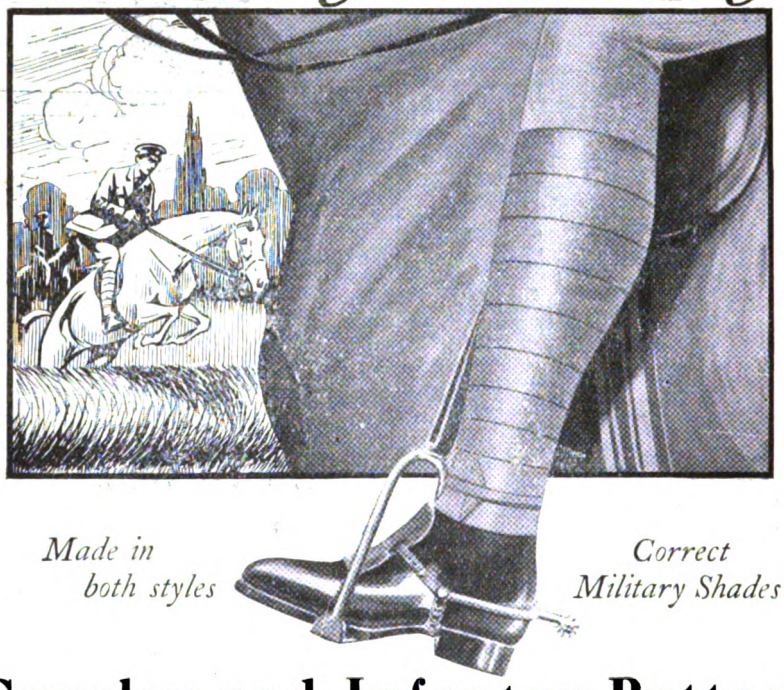

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THE ROYAL CHARTER.

AN announcement has already appeared in the March *Supplement* to this Journal that H.M. The King had been graciously pleased to approve the grant of a Royal Charter of Incorporation to the Institution of Royal Engineers; the bestowal on the Institution of this mark of royal favour is obviously an event of importance and calls for a special note in the pages of this Journal.

It is now some 47 years ago that the Institution was founded under its original title of the Royal Engineers Institute; during this period it has unquestionably served a most useful purpose, and its success has been so marked that to-day its members own much valuable property, a part of which has hitherto been vested in trustees. But something further was required to be done, in order adequately to protect the whole of the property of the members and properly to safeguard the future interests of the Institution. Both these ends have been secured by the grant to the Institution of a Royal Charter, which has had the effect of endowing the Institution with a legal existence distinct from and independent of its members. The Institution has, in consequence, become a "Body Politic and Corporate," and will, in its own name, be henceforth "for ever able and capable in law, notwithstanding the statutes of mortmain, to acquire, have, take and hold all the real estates, chattels, real and personal estate, belonging to or held in trust for the Institution." The Institution having acquired the status of a Corporation, it may not be out of place to say a few words here on the distinguishing characteristics conferred upon it, and their origin.

A Corporation is, needless to say, an artificial or fictitious person, and unites and personifies the group of transitory individuals who, for the time being, make up its membership; further, it enjoys a "kind of legal immortality"; that is to say, the Corporation possesses the attributes of unity and of perpetual succession. It is to Roman jurisprudence that belongs the merit of having invented the device of incorporation, which, it has been said, is a refined conception that has contributed more than any other human artifice to the civilization of Europe and the freedom of the States, since it was the Roman doctrine of Corporations that was brought in aid as the apt lever for the forces utilized in transforming the mediæval nation into the modern State. As the rights of natural persons may be said to die with them, the Romans conceived the

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idea that something should be done in order to preserve the particular rights of an Association of natural persons, when formed for some praiseworthy purpose, entire for an indefinite period, instead of allowing them to fall with the lives of the members who might, at any time, compose such an Association. Consequently, the establishment of Corporations for the advancement of religion, learning and commerce, and, indeed, even for social and convivial purposes, was permitted, when their existence was thought to be to the public advantage. Such Corporations, though consisting of numerous individuals, were treated by Roman law as forming a unity, with rights and liabilities distinct from those of its members individually, and were constituted either by a law, or by a decree of the Senate, or by an Imperial constitution; and Associations, the existence of which was not so authorized, were deemed to be illicit and illegal.

A juristic conception which endowed an Association of natural persons with the characteristics of the Roman Corporation proved so convenient that it was duly transplanted in these northern regions and became firmly rooted in our own Common Law, which, from very early times, has for a multitude of purposes treated the Corporation very much in the same way that it has treated the man. It is quite natural, also, that, in the days before the Legislature had established its control fully in all departments of a nation's affairs, the ruling Prince should, when desirous of encouraging the designs of those seeking combination for a laudable purpose, have had resort to the Roman device of incorporation in order to legalize such combinations. Hence it is that, for many centuries now, our Sovereigns have exercised an inherent power, the so-called prerogative of the Crown, to create Corporations for a variety of purposes, and this has been done by the grant of Charters. The exercise of the Royal prerogative in this particular manner is so old that its origin cannot be definitely traced; its first use is lost in antiquity, but public records are still extant to-day showing that grants of privileges by Royal Charter were made by Henry I. to corporate towns so long ago as in the year 1132, in connection with the protection of their manufactures. By such means municipalities were furnished with a form of government that never wore out; charitable and other trusts were secured to the objects for which they were formed so long as such objects should continue to be found; the protection, improvement and encouragement of trade were provided for; by and through such means, too, the growth of our Empire has been fostered. The great commercial companies, such as the Hudson Bay Company, the Honourable East India Company and the British South Africa Company, to name but a few, which have added vast territorities to the Empire, have all owed their existence to the exercise of the royal prerogative in relation to the grant of Royal Charters.

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At one time, the only method by which a trading company or an Association could obtain the status of a Corporation was by the exercise on the part of the Crown of its Charter-granting powers. However, a Royal Charter was not always to be obtained from the Crown for every promising enterprise; moreover, it was costly. The difficulty was met, so far as commercial organizations were concerned, by the formation of the so-called "Common-law Companies," which were unincorporated companies or large partnerships. However, the Government stepped in at the beginning of the eighteenth century in order to check "these dangerous and mischievous undertakings and projects," the particular mischiefs charged against them being the presuming to act as a corporate body; the famous Bubble Act, 1718, (6 Geo. I, c. 18) was passed as a measure designed to prevent the existence of unauthorized Associations. The Act proved a dead-letter and was, a century later, repealed; the Legislature, finding it must tolerate the Joint Stock Company, eventually passed a series of statutes for the regulation of that which it could not suppress. The scope of these statutes is so wide that to-day an Incorporated Society can be brought into existence under the Companies Act for almost any legitimate purpose, But no Corporation can, by the law of England, be created, even to-day, without the consent of the Sovereign; this consent is implied or presumed in the cases of Corporations existing by the Common Law or prescription, and it is expressly given in those cases where the Corporation is created by one of the means available to-day, that is to say, where it is brought into existence by the grant of a Royal Charter, or by Letters Patent, or under an Act of Parliament.

The grant of a Royal Charter as a means of incorporation continues to possess to this day a distinctive value of its own. This is no doubt due to the fact that the Crown will not exercise its prerogative of incorporation merely to enhance the standing of a Society or Institution which petitions for a Royal Charter; on the contrary, the status and reputation of a Society must have already been established before it can hope that favourable consideration will be given to the prayer of its petitioners. There was a time, of course, when Royal Charters were sometimes granted for purposes which were held to be, and undoubtedly were, contrary to the public interest; cases are on record in which Charters of Pardon were granted so wide in their terms as to amount to a dispensation to commit crime. It was this abuse of the royal prerogative that constituted the earliest grievances against the Crown; these grievances were dealt with by statutes in the time of Edward III. and Richard II. Again, Henry VIII. made free use of the royal prerogative and, by the grant of Charters to towns, was able to pack the House of Commons with many willing to vote as the King or his Ministers might direct. The Stuarts, too, were guilty of a

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number of excesses in the exercise of the royal prerogative, and to this fact it is largely due that limitations have been placed upon what, in olden days, was held to be an inherent power in the Sovereign. Since the passing of the Act of Settlement (12 and 13 Will. III., c. 2), it ceased to be possible to add to the Borough representation by the grant of Charters, or to tamper with existing Boroughs by the forfeiture and remodelling of their Charters. And to-day it is only on the advice of the Privy Council that the Crown can create a Corporation and invest it with privileges.

The procedure followed by those seeking a Royal Charter of Incorporation is to prepare a petition setting out the grounds which appear to entitle the Association, on behalf of which privileges are desired, to recognition. The petition, which is addressed to The King's Most Excellent Majesty in Council, must be accompanied by a draft of the Royal Charter prayed for. After the Petition has been lodged with the Clerk to the Privy Council, the fact of such a Petition having been presented to The King in Council is advertised in the *London Gazette*, and those who desire to oppose the grant of the Royal Charter are directed to notify their objections within a specified time from the date of the *Gazette* notice. This notice is no empty formality; objections, if any, receive most careful consideration if emanating from those who have a *locus standi*, as, for instance, bodies which have already received a Royal Charter. The Petition for the Charter and the Petitions, if any, against the grant, are in due course carefully considered and sent to such of the Government Departments as have a right to be consulted in the particular instance. These preliminary steps having been taken, the matter next is laid before the Privy Council: should their Lordships recommend the grant of the Charter, the final steps are taken by the Law Officers of the Crown and the Lord Chancellor. The Lord Chancellor's interest in the matter is affected more particularly by the mortmain clauses. In olden days, as is well known, the alienation of lands to Corporations was looked upon as of great detriment to the Crown and the lord, if any, of whom such land was held. In view of the abolition of many of the valuable incidents of tenure, the objection to a Corporation holding land is to-day not a serious matter; nevertheless, there are still certain statutory restrictions which apply, and hence it is that the Lord Chancellor, as well as the Law Officers of the Crown, require to be consulted; should they, in their turn, find the Draft Charter in order, The King in Council is asked to approve of the grant of the prayer of the petitioners, which he does by an Order in Council, upon which the Secretary of State for Home Affairs takes action.

It will be seen, therefore, that it is no easy matter to obtain a Royal Charter of Incorporation, and it may be of interest to place on record the fact that Royal Charters are so sparingly granted nowadays

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that, since the year 1867, it has been in respect of some 170 only of the Petitions that have been presented that this method of incorporation has been approved by the Sovereign. It is not surprising, then, that a Royal Charter of Incorporation should be so highly prized that Institutions which, in the early days of their existence, have had to be satisfied to obtain Incorporation under the Companies Acts should, when they have acquired a recognized standing, have been known to seek the royal favour in order that they, too, may rank with other Chartered Institutions and Societies.

W. A. J. O'MEARA.

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THE NECESSITY FOR ENGINEER INTELLIGENCE TO ENGINEER COMMANDERS IN WAR AND HOW IT MAY BE OBTAINED.

(*Second Essay for Cooper's Hill Prize*, 1922.) *By* PONTIFEX (Capt. and Bt. Major R. P. PAKENHAM-WALSH, M.C., R.E.).

BEFORE any operation, civil or military, can be undertaken, certain information must be forthcoming. This information must be sufficiently complete to allow the directing authorities to decide—first of all, on the feasibility of the whole scheme ; then on the best method of carrying out the operation if attempted ; and finally, to work out the preparations necessary for its completion.

In certain operations factors will be met with which are, necessarily, somewhat indeterminate. In war, more than in any other business, will these factors of uncertainty be encountered. They include, among others, enemy action, and questions of psychology and morale. To the military engineer, however, such factors are not of such importance as to his brother officer on the General Staff.

In every engineering problem, if all the facts are known, a clear-cut answer can be given to every question that may arise. The difficulty is, not so much the vagueness of the factors, as that of obtaining detailed information on all the necessary points. The success of engineering work, therefore, depends in the first place on the completeness of the information available. It is important for military engineers to have the most complete information possible about all engineering questions which may arise.

In the second place the success of engineer work depends on the time available for completing the necessary preparations. Special material may have to be designed, manufactured, and transported. Even if workshops were continuously available for this type of work, considerable time must elapse between the placing of an order and the delivery of the finished material on the site of the work. In great wars industry is so highly organized that such special orders must either wait their turn, or the output of certain other important munitions be delayed.

Even when special material has not to be transported from the home country, or the base, material will have to be found and prepared locally, all of which takes time. Further, to prevent interruption of other work, and unnecessary movement of technical labour,

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programmes of work must be prepared beforehand. In order that the necessary time may be available for all these preparations, the earliest possible information on all points must be forthcoming.

The information required will include not only details of the actual work to be carried out, but also data as to the material and labour available. To these may sometimes be added the state of communications to the site of the work, and the congestion or otherwise of workshops and factories affected.

Engineer commanders of all grades have two functions to perform. They are, in the first place, technical advisers to the commanders of the formations to which they belong or are attached. They are also responsible for the direction and carrying out of all Engineer works within their spheres of responsibility.

To perform their first function they must be prepared, at all times, to give an opinion to their commanders on engineering questions affecting proposed or current operations. To do this efficiently they must be well posted in the proposals for future operations, and in all points of engineer intelligence which may influence such operations. This necessitates the Engineer Commander having ready to hand all the information that he may require as to engineering works concerned, both in the area occupied by his own troops, and in that occupied by the enemy. This information will frequently need to be, in the first place, of a very general description, but, once the course of action has been decided on, detailed information must be forthcoming on all the factors affecting the situation. It is manifest that this information cannot be produced at short notice when it is required, if it has not already been obtained, co-ordinated, and collated by some organization. Military Intelligence, including that of peculiarly Engineer importance, may be divided into two headings :—that collected in time of peace, and that collected in war.

In peace time, intelligence is largely collected by Military Attachés. These officers are very seldom engineers, and, therefore, can do little in personally collecting information of engineer importance. Though peace-time intelligence organization is outside the scope of the present paper, a certain consideration of its methods must be made in order that its activities in war may be continued with the maximum efficiency.

Many Europeans countries publish very complete reports of all engineering organizations, and these can be obtained in the open market. Other information, though not so publicly presented, can usually be obtained through British commercial concerns. While no organization for obtaining this information appears to exist in peace, it is considered that it could be obtained before, or at the outbreak of war, by the Central Engineering Board at the War Office,

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which is the department most closely in touch with the civil industry of the country.

In war time, information as to the area occupied by the enemy is more difficult to obtain, but certain of our resources for obtaining information are largely increased. More money is available for agents, refugees are found willing to come forward with information, and an active Air Force is in being. Agents are seldom employed for their technical knowledge ; a very small percentage of refugees will be capable of giving technical information of any value ; and an Air Force can give few details of interest to an engineer.

Much reliance must, therefore, be placed on the reports of the troops as they advance. The number of engineers with the fighting troops is notoriously small for the work to be done. Engineer reconnaissance and transmission of reports must, therefore, be organized so as to produce the maximum of valuable information, with the minimum waste of time and man-power. To prevent such waste, it will generally be necessary to call for reports from Engineer reconnaissance officers, on certain definite points, though this will not exonerate them from the responsibility for forwarding all information of military or engineering interest.

No opportunity for gaining information should be wasted, and engineer reconnaisance parties should accompany any body of troops making important advances. Officers in charge of these parties should be given all the information available as to the ground to be covered, so that details may be verified quickly and new points rapidly recognized. It is a clearly proved axiom that in reconnaissance, the more one knows on setting out, the more useful will be the information gathered. It is essential that Engineer N.C.O.'s and men should be trained in this important duty, owing to the scarcity of Engineer officers.

The method of transmission of reports needs careful consideration. In the period of trench warfare in the Great War, bicycles became the standard means of communication within the Divisional Engineers. The value of the horse, however, soon re-asserted itself, as the pace of movement increased in the last six months of the war. The state of the roads, and the suitability of the country for the use of horses well forward, frequently made the latter by far the most valuable means of intercommunication available. It is of the greatest importance that subaltern officers should be trained to make full use of their own horses, and of mounted N.C.O.'s.

Engineer officers in action have much too much to do to write reports on all matters of engineer interest which they may notice. C.R.E.'s should, therefore, have on their staffs, officers available to visit units and individual officers frequently, to obtain verbal information of all natures. In this way very complete information on all points should be available.

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No matter how energetic they may be, Engineer officers cannot expect to cover the whole ground, and some reliance must be placed on reports from non-technical units, especially the Infantry. To get the best results from this source of information, very close personal touch must be maintained between Engineer and other officers. Only by constant intercourse will troops come to realize what are the functions of Engineers, and till they do so they will not be in a position to give the Engineers useful information, which they may pick up in the course of their operations.

This personal touch cannot depend on organization or regulations. It can only be obtained by the officers of Engineer units constantly visiting and talking to officers of other arms, especially of the Infantry. Only thus will the Infantry officer get to know exactly what information is of use to the Engineers, and how it can best be transmitted to those who require it.

Besides the information gained from the fighting troops, valuable information will be gathered from other sources. As this information will cover areas not yet reached by the fighting troops it will be of special value. It will, in the main, be drawn from agents and prisoners of war; or from organizations which in peace-time are in charge of records and statistics as to means of communication, water supply, factories, workshops, etc. This is really an extension of peace-time intelligence work, and illustrates the importance of a sound organization built up before war breaks out.

As regards agents and the interrogation of prisoners of war. The organization of these services must be in the hands of the Intelligence branch of the General Staff. This raises the question of the responsibility for organizing the collection and collation of Engineer intelligence. Though it would seem at first sight to be correct for technical experts to give instructions for the collection of specialized information, and to select suitable persons for obtaining it, it will be found, on investigation, that such a course is impossible. It is vital that such a highly confidential organization as espionage and secret service should be controlled by one very small department. Otherwise secrecy may be sacrificed, work duplicated, and multiplicity of agents working for different masters may defeat each other.

Apart from this, all information about the theatre of war or the enemies' country, however trivial, or however technical, may contain items of vital importance to the Operations Staff. The Intelligence branch of the General Staff must, therefore, be the sole authority for the collection of information. Though Engineer Commanders may collect Engineer information from their own organizations, it is their duty to pass it on to the Intelligence branch of the Staff.

It is also the duty, however, of Engineer Commanders to inform the General Staff as to the points on which Engineer intelligence is required, and to suggest the most suitable means to be employed

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in its collection. They may, at the request of the General Staff, arrange for its collection themselves.

If the information be in the hands of the General Staff, how then can it best be made use of by Engineer Commanders? One solution would be, to have a definite Engineer department of the Intelligence Staff which would arrange for the collection, collation, and distribution of all information of importance from an engineering point of view. For collection, this department would have to work through another sub-branch of the Intelligence Staff. All effort in this direction must be under unified control, though, as has been stated, power may be delegated for certain purposes. As to the collation of Engineer intelligence, some Engineer branch would seem to be necessary. Experts are required to arrange and produce, in the most useful form, most of the technical information received in the Intelligence Offices. Distribution of technical information would seem to be suitable work for an Engineer Intelligence Branch. But it is important that there should not be overlapping in this duty. As it is frequently necessary to include Engineer information in summaries distributed to all arms, it is important that the work of distribution should be co-ordinated by one Staff.

It is open to question whether an Engineer branch of the Intelligence Staff would be in sufficiently close touch with the needs of the Chief Engineer Officer of the Forces in the field, or be sufficiently accessible for advising or informing him on engineering subjects.

An alternative solution is to have a department of each Engineer Commander's Staff responsible for preparing for his use all the information he may require. This department, which will be referred to hereafter as the Engineer Intelligence Bureau, should obtain its data through the General Staff by means of *liaison* officers. These officers, having the entrée into the various departments of the General Staff, would see that all incoming information of interest to the Engineer Commander is transmitted to that officer's Intelligence Bureau. They would also be responsible for informing the General Staff on what points information of Engineer interest should be obtained, and for advising them on methods for its acquisition. The material thus collected could be collated in a suitable form for technical use by the Engineer Bureau. It would then be available for issue to the troops under the authority of the General Staff. Such an organization would further allow of the short circuiting of information of urgent importance, without interfering with the normal working of the Intelligence Staff. Being under the immediate control of the Engineer Commander himself, the Bureau would be more accessible to him than if it were under the General Staff.

In its simplest form this Engineer Intelligence Bureau would be represented by the Divisional Engineer Intelligence Officer referred to above. He would pass all engineer information obtained to the

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General Staff, and also, if necessary, to the Engineer Intelligence Bureau of the Corps. Such an organization would ensure that all available information, both as to possible future work, and to completed work, should be in the hands of a definite officer from whom it could be obtained as desired. This would relieve executive officers of the necessity for frequent reports, or for answering the countless queries which do so much to keep them from their own proper duties. Information of special Engineer interest could be passed rapidly up and down the Engineer chain of administration without interfering with its normal communication through General Staff Channels.

At General Headquarters the organization would naturally reach its maximum complexity. Sources of information are available which, with the approval of the General Staff, can best be tapped by Engineer organizations. Special experts are available, such as geologists and chemists who would collect specialized information and express it in its most useful form. Interchange of ideas and information can be arranged with the Engineer Staffs of allies, or with the civil industry at home or abroad. The collection of all this information would be the duty of the Engineer Intelligence Bureau.

While almost all of the information thus collected should be transmitted to the General Staff, it would normally have to be converted into a form of more direct utility. For example, a cross section showing the geological formation of a certain area would be useless to a General Staff Officer. An estimate, on the other hand, as to the depth at which water could be obtained, and of the time necessary to sink a well to that depth under the given conditions might be invaluable to him. Again, details as to the nature of rolling stock, curves, gradients, and lengths of sections of railways, must be translated into terms of trains and tonnage per diem running over a particular line. The information may, in the first instance, be obtained through General Staff channels, but it will be passed to the Engineer Bureau for digestion and conversion into terms on which operation and administrative plans could be built.

Such conversion must take place in the offices of an organization which also knows the existing resources of the army and the country for repair, maintenance, and construction. This is only available in a centralized form in the office of the Engineer Commander at General Headquarters.

To perform its functions most efficiently, very close touch must be maintained by this Engineer Bureau with the General Staff. This can only be done in the higher formations by Engineer *liaison* officers living with the General Staff. Visits of working members of the Staff of Engineer Commanders to the General Staff, however frequent, can never achieve that complete mutual understanding

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that can be reached by an officer living with the Staff and thoroughly understanding its needs and desires.

It is as clear at General Headquarters, as it is among the fighting troops, that personal contact and comradeship with those for whom they are working are necessary for the Engineer officer. The Engineer, to be efficient, must look far ahead and not await the requests for assistance from the General Staff and fighting troops. These may only come when plans are fully crystallized or difficulties actually encountered. It may then be too late to carry out satisfactory engineer work if the Engineer Commander has not started his preparation before the need became manifest. He can never look ahead, or take rapid action, if he is not supplied with the most up-to-date and complete information. This information will only be available if a sound organization for its collection exists in the closest co-operation with the Staff and the other arms.

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ORGANIZATION OF ENGINEERING WORKS IN THE GREAT WAR.

By MAJOR-GENERAL SIR GEORGE K. SCOTT-MONCRIEFF, K.C.B., K.C.M.G., C.I.E.

THE experience of the Great War, where not merely armies, but nations were engaged, brought to light, among other important, but half-forgotten foundation truths, the intimate connection between military science and constructional engineering. Not *mechanical* engineering, be it noted. For that aspect of engineering science had never been forgotten. Ever since mankind first waged war, the improvement of weapons has been constantly borne in mind, and the skill of the mechanic has always been in request. That skill, used in the arts of peace for innumerable industrial purposes, was ever in demand for implements of war from the rudest weapons of the savage to the complicated and elaborate machinery of modern artillery by land and sea, and the more recent achievements of science in the air. When the expression " An Engineer's war " is used, therefore, it generally implies an " engine " of some kind. It assumes the " engineering trades," that is to say, those who work in factories equipped with elaborate machinery and tools, who convert the raw materials of steel and other metals into ingenious and wonderful combinations, formed for the utilization of natural forces, into channels for the achievement of definite purposes, it may be of beneficent value, or of terrible destruction. In war, the soldier, as a rule, has nothing to do with their production, except, possibly, in an advisory capacity. His business is to utilize them when constructed ; he looks to the community, on whose behalf he is waging war, to supply him ; and the work of manufacture and supply rests with the Statesmen, the Ministry of Munitions, and the great industrial army—composed to some extent, as we have seen, of women, who are non-combatant.

But there is another form of engineering, which in the parlance of the profession is known as " civil " (as opposed to " mechanical " and " electrical ") which in times of peace is engaged in a constant warfare with the forces of nature. This is the profession which builds our railways, constructs harbours and canals, brings water supplies to our cities, carries out large schemes of drainage and sewerage, plans our factories and makes our roads. Its work is

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often unrecognized or not appreciated because it is carried out with smooth and regular continuity. If the perfection of art is to conceal art, the work of many such an engineer is that of a great artist, only the concealment is so successful that many fail to recognize that there is any art at all. In a great city, for example, with its arrangements for water supply, lighting, sewerage, etc., how few of the inhabitants have any idea of the immense labour and exquisite science involved in the regular supply to the community of the services which they enjoy daily! But if any cessation of those services occur, they realize, with indignation, their dependence on the profession, and in demanding redress, possibly do scant justice to the immensity of the problems to be overcome.

It is obvious that the greater the population of our cities, and the more complicated the conditions of civilized life, the greater are the difficulties presented thus to the civil engineer in respect of the regular services which he thus has to render to the public. He has, it is true, greater facilities than his ancestors, greater means of transport, a wider and better range of materials, an enhanced degree of scientific knowledge, and better tools for his work, and more highly skilled specialists to use them. Yet essentially the problem for large cities to-day is the same as what it was when Appius Claudius first brought water supplies into the Eternal City, and, the work of the military engineers in modern warfare does not differ, except in detail, from that of the unknown chief engineers of Hannibal and Alexander who succeeded, in the one case, in getting an army, including elephants, across the Alps, and in the other case in taking a pontoon train from the Indus to the Jhelum, through the ravines of the Salt Range.

In modern civil life, the science of engineering is necessarily so subdivided that any large scheme, though initiated and controlled by some master-mind, is largely dependent on specialists for its successful and economical execution. If this is the case in the comparatively restricted and deliberate operations of peace, it became infinitely more necessary in the stupendous and swift operations of engineering in the Great War. There the co-operation of all experts had to be sought and co-ordinated. This, so far as the British Army was concerned, was the main occupation of one officer at the War Office, known officially as F.W.5. His duty was to see that nothing was left undone, from the placing of a contract for materials ready for use, and costing, perhaps, millions sterling, to the issue of a pass for a British workman proceeding to France, in a hurry to repair a machine. But the work of design and of execution was in other hands, his duty was that of a switch board or a clearing house.

As an instance of this co-operation may be mentioned the greatest

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water supply scheme ever known in the annals of war—the laying of the pipe line from Egypt into Palestine. The entire success of the operations against the Turkish Army in the Isthmus of Suez depended on this. A project for carrying the water across the isthmus from Kantara, on the Canal, to El Arish, on the Palestine frontier, was worked out by the engineering authorities in Egypt. The distance was some 90 miles, the quantity required daily was 600,000 gallons. It was proposed in this scheme that there should be four relays of pumping stations, with reservoirs, in the total distance of 90 miles, and that 60 miles of 12-in. piping and 30 miles of 10-in., as well as certain engines, pumps and machinery for the reservoirs, etc., would be required. This was the scheme worked out on the spot, and cabled to the War Office.

The business of the War Office was to find the materials, viz. :—pipes, pumps, etc. The contract for pipes was placed in America, for no firm in England could produce what was required at such short notice. The War Office sent an expert to America to see the contract through, and to accompany the pipes to Egypt.

The Royal Navy specially escorted the ships bringing the piping. The Cairo Waterworks Company designed the filter plant, introduced new fool-proof devices, and installed the plant. The Suez Canal Company laid pipe syphons across the canal from west to east, this work entailing various diving and dredging operations. The military engineers of the force built the engine houses, settling tanks, etc., on the east bank of the canal, and (most difficult task of all, perhaps) laid the pipes. The total weight of pumping machinery and stores transported from overseas was over 10,000 tons. Special arrangements had to be made at Kantara to receive this ; sorting yards, workshops, etc., had to be constructed, and a wharf built of sufficient size to berth the ocean-going steamers which brought the materials. Finally, the War Office was asked to find and send out the best available expert on water works engineering to act as advisor and critic. He was found and went out accordingly and pronounced it all very good.

The scheme was initiated in July, 1916, and the Nile water flowed into Palestine in February, 1917. In spite of certain minor mistakes and failures this was a wonderful feat, and it was made possible by the co-operation of many active and capable brains.

By similar, though, perhaps, less clearly defined methods the whole of the works involved in the war were carried out, both in the United Kingdom and in each theatre of war.

Truth, however, obliges one to state that the one place where co-operation was faulty was in the spot where, above all others, it should have been most perfect, namely in the War Office itself. There was no engineer on the Army Council who could grasp the

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significance of policy or aims of the General Staff with their possibilities or limitations from an engineering point of view, and translate them into orders for the engineering executive. It is obvious even to the veriest amateur that the evolving of schemes based on policy must take some little time to work out in detail, that materials for such schemes must be collected from some source, and that even if the end in view be similar to another scheme already worked out, there must necessarily be differences in circumstances which may call for separate treatment. Yet it often occurred that military operations of great importance, which depended to an enormous extent for success on engineering, only came to the knowledge of the head of the branch concerned by accident, having even escaped the wide-spread vigilance of F.W.5. It was apparently thought that an engineering scheme could be brought into being with the same readiness that a battery of horse artillery could come into action. Nor was this the only faulty part of War Office organization. There was no one head of engineering, not even although the main responsibility for works rested on the Master General of the Ordnance. Railway work was under the Quartermaster General (until a Director General of Transportation was appointed). Inland Water Transport was also under the Q.M.G. and, although there was no definite order exempting this branch from the normal rule that all building and constructional work should be done by the recognized Works Branch, from the first it did its own works. It did this extraordinarily well, and with celerity and economy. But the fact of there being two or three works departments in the Army meant inevitable competition. Now, competition may be the soul of trade, but in military operations it is anathema. It was bad enough to have the Ministry of Munitions competing against the War Office for materials and labour, and, regardless of expense, introducing complications into the market, but it was ruinous to have two or more branches of the War Office competing with one another.

It was to a great extent the same in the theatres of war. There was no representative there of the Master General of the Ordnance, so all engineer services were placed under the Q.M.G. But many of these services affected Operations with which the General Staff alone and not the Q.M.G. is concerned. To obviate this confusion, the chain of responsibility for orders became largely a personal matter, the Chief Engineer taking his instructions verbally from the General or his Chief Staff Officer. It was not sound administration, and it involved all sorts of friction, but it meant delivery of the goods. At G.H.Q. there was an officer who was "the opposite number" of F.W.5., and whose business it was to know everything that was being proposed, and everything that was required from England

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to carry it out—whether stores, materials, tools, machinery, plant or personnel. Late at night he collected his reports for the day, and in the silent hours would keep up an animated talk over the wires with F.W.5. in Whitehall. Next day he would send a formal demand through the official channel, but long before the ink was dry on the paper, F.W.5. had switched off the demands to the proper quarter and was in a position to say how the problems were to be met.

Thus, although the organization was about as bad as it could well be (and this fact was brought to the notice of an important Committee immediately after the war, so as to avoid such mistakes in future), the work was being energetically done owing to indomitable pertinacity and good will on the part of individuals.

In considering the actual work to be done, it is well to bear in mind the difference between the rapid temporary works executed in the field by Sappers and Pioneers, and the more substantial semi-permanent work entailed nowadays by heavy artillery, tanks and motor traffic, as well as that necessitated by the vast numbers of men and vehicles in a modern army. No doubt, the experience of South Africa with its wide spaces, and the war against the Boers with their comparatively small numbers and preference for mounted tactics, was a misleading introduction to war in countries like France and Belgium. More probably the comparatively small armies which had been put in the field by our country in its numerous wars in Asia and Africa had tended to obscure the fact that, in addition to those regularly organized units of military engineers whose primary duties were inseparably connected with tactical operations, there is required in modern armies an organization of some sort dealing with engineering problems of accommodation and communications, and this necessity increases with the size of the armies concerned. In the Indian Army such an organization has always been recognized. In addition to the companies of Sappers equipped with entrenching tools and light bridging plant, it has been customary to have with brigades and divisions certain field engineers unattached to units, whose experience in peace has been on civil engineering works and whose functions in war are to arrange for the carrying out (generally by civil labour, locally obtained or imported) of similar works, such as the construction of roads and of bridges, the building of huts or other accommodation, the fortification of positions and the attack of fortified places of the enemy. Such an organization was not existent in the British Army at the beginning of the Great War, but of necessity it came into being early in 1915. Thus, while it happened that the pre-war training of our field units of engineers had, very rightly, been more and more associated with the tactical development of other arms, and had been essentially part of the

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responsibilities of divisional generals, the scope of engineering as applied to war had been limited to these functions only, and the wider application of that science had been imperfectly grasped even by those whose special duty it was to visualize war in all its bearings. Even the most recent of great wars had given scant indication of the value of this. In Manchuria there were examples of the great tactical value of field defences, both from the Russian and the Japanese side and these examples had been studied with some effect in our army. But, beyond the fact that some new materials (such as steel and concrete) were employed in that campaign for the first time, there were few indications of the great value that might accrue to a commander of the extended use of engineering skill in the operations of war.

A superficial consideration of this matter might lead to the supposition that any developments of the kind indicated might apply only to work behind the fighting zone, that improvised works based on local materials only would be possible in that zone, and that, therefore, any assistance which a commander might obtain from an engineering organization at the base (in our case at the War Office) would apply only to the Lines of Communication and not to the operations of the Field Army. This view of the case was embodied in the Field Service Regulations of our Army and experience proved that it was erroneous. With large armies, and especially with a prolonged period of trench warfare, it was found that local sources of supply of materials were speedily exhausted. More and more as the campaign went on the engineers of the fighting zone depended on their base for supplies, and in this way the engineering authorities at the War Office became more and more intimately connected with operations and, therefore, with the policy of the General Staff whose intentions supplied the initiative. The most important engineering problems then became not merely how to build huts, defend naval bases, or to supply requisitions for pumps and boilers, but how to bring the science of the engineer to bear upon the problem of the defeat of the enemy. From this consideration rose the provision of tanks,* of accelerated and improved mining, of rapidly constructed

* The connection of the War Office, as represented by the D.F.W.'s branch, with the initiation and evolution of the tank was greater than is generally supposed, or than would be inferred from the proceedings of the Court of Award that considered claims of applicants in October, 1919. Misunderstanding on this subject (which was not unnatural, considering the published information) led to some unmerited criticism; among others, by Major-General Sir Charles Callwell, K.C.B., in his witty book *The Experiences of a Dug-out*. On being informed of the facts by the writer of this article, he kindly promised to amend it in any future edition. The true version of the case was known to Lord Moulton who was Chairman of the first Committee on Awards, and to Mr. Justice

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and powerful bridges, of better signalling equipment, of anti-aircraft searchlights, and many minor inventions. From this arose a vast series of experiments, some of which were successful, some only proved the futility of certain proposals of hare-brained enthusiasts, and some reached a stage which promised well but were not completed at the conclusion of the war.

As may be readily inferred, the engineering branch of the War Office, even with the restrictions indicated above, rapidly expanded to meet the developments of the various campaigns. At first the work thrown on this branch was negligible, less even than the normal routine in time of peace. The arrangements for the defence of our home ports had been all worked out in various defence schemes in time of peace, and the local commanders knew exactly what to do on the outbreak of war. The Expeditionary Force took with it to France some of the best officers of the department concerned, who went prepared to carry out any work that might be necessary. But their successors, brought in from the Retired List, or from half-pay, had no work, at first, to do, for there was no policy to be carried out at home or abroad that involved any engineering duties. An organization for supply of materials was prepared, but until some indication of the development of the campaign appeared there was nothing that could be done, except watch the state of the markets for materials and labour. There was thus the extraordinary anomaly that, while every other branch of the War Office was working at high pressure, this alone had practically nothing to do.

Then came the call for the new army and increased hut accommodation, and at once the whole machinery of the works department sprang into life with an energy and momentum which increased in volume never ceasing till the close of the war.

Sargent and the members of the second Court, as well as to the Solicitors General (Pollock) and Attorney General (Hewart), who conducted the case for the Crown. My opinion of these legal dignitaries was that, as no officers of the D.F.W.'s Staff claimed any reward, and as the Court was convened for the purpose of examining such claims, and not vindicating the War Office, there was no need to refute any inaccuracies as to the latter that might have appeared in the proceedings. Moreover, it was apparently thought the reputation of the War Office for sloth and ineptitude is already so established in the public mind that any attempt to whitewash it would be received with incredulity. Evidently in an invention of this sort there must be many who had a share, and as long as the result was successful, the identity of the individual, or the office, is quite immaterial. As to whether officers of the fighting forces, whose business it is to defeat the enemy, should claim pecuniary rewards for their share in the matter, is, of course, a matter of opinion which need not be here considered. Anyhow, it must be a source of legitimate satisfaction to the Corps of Royal Engineers that both in the inception, the evolution, construction and fighting of the new engine of war, they had a notable share.

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There grew out of a comparatively small nucleus no fewer than twelve subdivisions of the Works Organization in the War Office. These were known as F.W.1, F.W.2, etc. Of these the functions of F.W.5 have already been touched upon, and it will be observed that his duties were entirely concerned with works in the field. So also were the duties of F.W.8, the Chief Mechanical Engineer, and of F.W.9, the Chief Electrical Engineer. Both these officers had a large expert staff under them, and although each had some duty to do in connection with works for the defence of the United Kingdom, the greater part of their work lay overseas. There were others whose duties lay entirely within the limits of the British Isles. Such were F.W.2 who had control of the large plans for hutted camps and remount depôts and hospitals at home, F.W.3 who carried out a far larger scheme for the fortification of our home ports and naval bases than had been undertaken since the days of Lord Palmerston (and in some respects it was a greater scheme than even that celebrated one, though it cost far less), and F.W.7 whose duty it was to provide (until 1918) for the rapidly increasing needs of the Royal Flying Corps in aerodromes, aircraft depôts, etc. The office accommodation for all this great organization soon overflowed the congested limits of the War Office. Some were in a hired hotel near Blackfriars, some in St. James's Park, some in Woolwich Dockyard. There was a branch organization at the South West India Docks, there were five factories for signalling gear in and round London, there were experimental establishments at Claygate in Surrey, and on Woolwich Common.

Each of the twelve subdivisions was under the control of a senior engineer officer who had very wide powers of action, and practically a free hand to do as he thought best, with the reservation that he must keep the head of the branch informed as to what he was doing. Each had under him a staff, greater or less according to the magnitude of his operations, of officers, mainly civil engineers, wounded or invalided from one of the campaigns. Somehow or other, the round pegs fitted into corresponding holes marvellously well. The utmost harmony and co-operation prevailed and not a single case of "disciplinary action" was necessary in any of the staffs of officers, and hardly any among the subordinates. Valuable co-operation also came from the civil engineering profession. In the very early stages of the war the Secretary of the Institution of Civil Engineers was called into consultation as to contractors, individual candidates for commissions, etc. Later on (in 1915) that Institution was asked if they would appoint an advisory Committee to go round works in progress, criticize and advise (though not assume any responsibility for execution or administration). This they not only did, appointing a most influential Committee of present and past and future Presi-

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dents of their Council, but they did all their work gratuitously, and, it need hardly be said, their technical advice was most valuable. It was considered right that in a matter where many millions of public funds were being expended, the very best technical opinion in the country should be directed to the procedure.

Contractors of great experience also offered their services at very moderate remuneration, for the execution of some of the great works, and without their expert aid progress would indeed have been far slower than it actually was.

The advent of the Ministry of Munitions in the spring of 1915, affected this branch of the War Office very little. It took over the manufacture of hand grenades and trench mortars which had been consigned to the Works Branch during the previous winter. But this really ought never to have been considered an engineer service at all, and was only made such because the artillery, to which branch it belonged, could not conveniently take it in hand. So in handing it over to the Munitions Ministry, the Works Branch felt they were only parting with what in truth never belonged to them. The Ministry of Munitions also took over the consideration of inventions, an immense relief to the Works Branch, and to some extent carried out experiments. Beyond this they did not touch any of the multifarious R.E. Stores, nor concern themselves with the provision of any plant or machinery required for works. Indeed, in some cases the Works Branch of the War Office built magazines or storehouses for materials or ammunition provided by the Ministry of Munitions, though, as a rule, that Ministry did its own construction work.

Herein the practice of our English administrators differs somewhat from that of the Americans. In the U.S.A. specialization is carried to what we consider extremes. In the American Army, if a hospital, for instance, is built, one department surveys the site, another arranges for the water supply, another for the lighting, another for the drainage, another for the actual building.

Our English method is to have one officer in charge of each important work, or group of works. He need not be a specialist, for he has, or should have, under him, specialist subordinates, but he must know enough about each man's job to be able to co-ordinate and to exercise capable supervision. "I don't want," said Lord Kitchener, discussing this subject, "an Engineer officer who can only take photographs;" and another distinguished general expressed his desire in emphatic language for some one person to answer to him for the actions of all. It was found that even with the best and most capable contractors the existence of a responsible officer was an absolute necessity. These officers were found as a rule from the Retired List, some of them men who had held very important positions at home or in India a few years before, and several of

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them were men of considerably advanced age. Many of them in course of the war served in the field, one, indeed, becoming Chief Engineer of an Army, rising to that position by strong character and merit.

In a vast and varied number of different works it was inevitable that there should be some complaints, but these were marvellously few, and the causes were not always due to engineering mistakes. The hutted camps in England in the first winter of the war, one of the wettest seasons on record, were a source of much legitimate grumbling. But the sites were not chosen by the Engineers and were often most unsuitable from a works point of view. At the outset the Engineers' proposal was that, while good dining rooms, recreation rooms and kitchens, etc., should be built at once, the provision of sleeping accommodation should be postponed till 1915, the men, meantime sleeping in bell tents with boarded floors. But the Army Council insisted on sleeping huts being provided concurrently with the other accommodation. To provide both in the few months between the outbreak of war and the rains of November was impossible.

Another complaint was the shortage of sandbags. This was more or less a mystery, for although it undoubtedly existed in the firing zone, the most searching enquiry, carried out at the time of the battle of Loos in September, 1915, elicited the fact that no requisition for sandbags at the forward " R.E. dumps " ever had to be refused for lack of material. That the sandbags were misused in all manner of ways was beyond any doubt, but there was never any shortage of supply, in fact at the very time English ladies were painfully making up sandbags with infinite trouble, millions were being poured into France every day from Calcutta and Dundee, and there were mountains of them at every forward depôt.

The last, and, perhaps, the worst complaint was about the School of Aerial Gunnery at Loch Doon. As this was the subject of a Parliamentary enquiry, it may be, perhaps, sufficient to say that the Engineers were exonerated from blame in a matter where there had been evidently hasty judgment as to selection of the site.

That the magnitude and efficiency of the work did not attract public notice at the time of the war is, perhaps, not surprising in view of the other deservedly admired features of administration, such as the feeding of the troops, and the treatment of the sick and wounded. Admirable and admired as these were, it is perhaps, not too much to say that those who were behind the scenes knew that they were even more efficient than the public were led to believe. The marvellously complete arrangements for the great bakeries at Dieppe and Rouen, for instance, or the enormously complicated and perfectly working arrangements for the wounded at great hospitals such as

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those at Etaples and Le Tréport have never been adequately described. But in any case such matters as these, appealing, as they do, to the most urgent of human needs, would attract more attention than any work of engineering skill. Moreover, as has been already pointed out, the works of engineering depended on the developments of the situation. Troops have to be fed and the wounded have to be treated under *any* conditions of war, and weapons, clothing and ammunition have to be provided anywhere, but the conditions of a campaign alone have to determine the works to be carried out, and the nature of those works govern the plant and the tools required.

That the actual results were satisfactory is, however, proved by repeated and emphatic allusions to it in the dispatches of the successive Commanders-in-Chief and in one of these Sir Douglas Haig departed somewhat from custom in commending not only those who served under him, but in thanking the War Office Staff and manufacturers for their co-operation.

The complaint about the sandbags, though it fell on those who were already striving their utmost, and with genuine success, to keep their comrades in the fighting line supplied with accessories of combat, was a not unwholesome stimulant to continual endeavour. The personal nature of the relations between the Engineers of the front line and those looking after their wants in London has already been alluded to. It was the pith and marrow of the engineering enterprise generally. So much was this the case that when in the third or fourth year of the war it was proposed that all supply of equipment, engineering plant and stores should be placed under the newly appointed Surveyor General of Supply, the proposal was negatived, not because the newly-appointed official was not capable of appreciating the position, but because the valuable personal link might be endangered. It had proved a remedy for defective organization, it had been a living link between the front line and the base, and we could not afford to risk any weakening of the chain merely to satisfy academic arguments. The case, thus put before the Surveyor General, was wisely accepted by him. All he asked was that his experts should be given every opportunity of examining the procedure, and freedom to criticize. This was readily granted and the advice of the experts was to leave well alone.

Yet this co-ordination of the needs in the field and production at home was not accomplished without price. On both sides of the Channel the strain was unspeakably severe. It meant absolute break-down in more than one instance, and sudden death resulting from sheer failure of mental and bodily power.

The one dominant thought among those whose duty kept them unwilling purveyors at home for their more fortunate comrades in the fighting zone was that under no circumstances must the latter,

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in their tremendous difficulties, be "let down." It was common knowledge, based for the most part on frequent visits to the front, how every possible advantage was being taken of local resources, how workshops and factories at Bailleul, Hazebrouck, Armentières, Bethune, the Somme area and many other places were being used for all they were worth, and in some cases for purposes for which they were not originally intended. It was known how the forests and quarries of northern France were being turned to account on a vast scale. Yet it was also known that, however heroic was the endeavour and ingenious the skill of the Engineers in the field, they had to deal with an enemy that had behind him the resources of Belgium and Germany, and who had thought out the means of applying those resources to war with characteristic thoroughness. Therefore it behoved engineers in England to meet the enemy in this as in other spheres of activity, and, if possible, to beat him.

How they did so is a matter of history.

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MODERN FORMS OF CENTRAL HEATING.

By Brig.-General W. BAKER BROWN, C.B.

THE Royal Engineer is always on the look-out for any forms of construction or types of fittings which will enable him to effect economy in construction, so that he can get a little more result from his attenuated financial allotments.

Some modern forms of Central Heating in which the writer is interested, and which claim to give comfortable warmth with economy both in working and first cost, seem well adapted for many military buildings, and a short account of the principles and practice of this new system should be of interest.

The general principles of Central Heating are well known. Instead of the English practice of installing small heat-producing units in each room, one large heat-producing unit is established for a whole house, or even sometimes for a group of houses. The source of heat may be by burning coal, coke, gas, wood or refuse, and many suitable forms of furnace are on the market.

It is in the distribution of the heat that we find great variety, and in some cases great complexity in the apparatus, but the various systems may be classified by the agency used to convey the heat—air, water, steam or electricity. Of these electricity is, perhaps, the nearest to the ideal method, but is ruled out at present by the question of cost. Of the others, steam, especially at high pressure, involves considerable accuracy of fitting and consequent expense, while air conveyed in pipes or ducts is difficult to regulate because it is easily compressible. Of the systems using pipes or ducts, hot-water circulation seems the best for a private house. It has, however, the disadvantages of requiring a considerable length of pipes and apparatus, the circulation of the hot water is troublesome to regulate, and the heated air is uncomfortably dry. Also, in common with all systems which provide for heating each room independently, there is very little circulation of the air, producing a stagnant, stuffy feeling which is particularly offensive to the British skin, though tolerated on the Continent. Within the last few years a system of heating by hot air has been evolved in the United States which meets all the above objections. It has spread rapidly all over the United States and Canada, where the number of installations must much exceed 500,000, and is being added to at the rate of at least 100,000 a year.

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These figures are sufficiently striking to ensure that the new system should be fully investigated by all interested in house warming. Simultaneously with this development, a considerable change has taken place in the views of ventilating engineers. The theory which at present occupies the text-books is that to ensure pure air it is necessary to remove all but a trace of the carbonic acid which is expelled from our lungs in the process of breathing, and that the only way of doing this is by expelling the whole of the air in a room and replacing it by fresh air from outside. All systems of ventilation are, therefore, based on changing the air of a building or room two to six times an hour, and replacing it with fresh air This again reacts on the heating arrangements, as the heat which has been transferred from the heater to the air is taken out from the room with the air and the new supply has to be heated afresh. In other words, the heating apparatus has to be large enough to heat up the air of the room every 10 to 30 minutes. The latest ideas on ventilation involve considerable modification of this theory.* In the first place, carbonic acid is not in itself poisonous. Our lungs always contain about five to six per cent. of this gas, so that it is obvious that air with this percentage cannot be poisonous. The reason why the presence of carbonic acid is regarded with suspicion is that it indicates a deficiency of oxygen and is also a measure, to some extent, of harmful impurities exhaled in the process of breathing. Actual experiment with human beings has shown that, provided certain conditions are fulfilled, the presence of 13 per cent. of carbonic acid in air causes no inconvenience.

Then, again, it must be noted that the fouling of air is not confined to breathing. The vapours from the skin are very considerable, and experiment has shown that a supply of pure air to the skin is only second in importance to the supply of air for breathing. To ensure comfort it is further necessary that this air supply shall reach a certain standard of warmth and moisture. If the air is too cold it chills the body unduly, if too dry it tends to draw an excess of moisture from the skin, if too wet, the evaporation from the skin is checked. Modern theories of ventilation, therefore, require continual *movement* of *warm*, *moistened* air.

Further experiment has shown that, however closely we may shut doors and windows, there is always a movement going on of the air in the house, air entering, not only through the "chinks" of the doors and windows, but through the walls. Professor Carpenter states :—"Recent experiments made in a building of ordinary schoolhouse construction indicate that in mildly cold and quiet weather such leakage equals the cubic contents of a room or building approximately once in each ninety minutes."†

* See *Heating and Ventilating*. Professor Carpenter. Chapter 11.

† *Heating and Ventilating* —Seventh Edition—Paragraph 239.

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Everyone is familiar with the difficulty of keeping the smell of cooking out of a room showing that the warm air from the kitchen has penetrated the passages and rooms. With open fires the movement of air is even more considerable; every fire draws into a room large amounts of air from under the door and round the windows, and passes the greater amount of this air up the chimney. The air movement so produced is much more than is required for efficient ventilation and usually produces an uncomfortable "draught."*

Much of the change of air required for good ventilation is thus effected for us by Mother Nature.

The new form of central heating, called "Pipeless," is based on the principle of assisting and using the forces of Nature.

It is a hot-air system. The air is warmed by contact with a large stove or furnace of cast iron which is contained in a casing of galvanized sheet iron, so designed as to compel the air to pass in very close contact with the sides of the furnace. The products of combustion pass straight from the furnace to a flue and do not contaminate the air of the house in any way. The furnace with its hot-air chamber, is usually placed in a basement or cellar, and is connected to the middle portion of a grating placed near the centre of the ground floor of the house. From this grating the warm air fills the staircase and passages, and gradually penetrates to every room of the house.

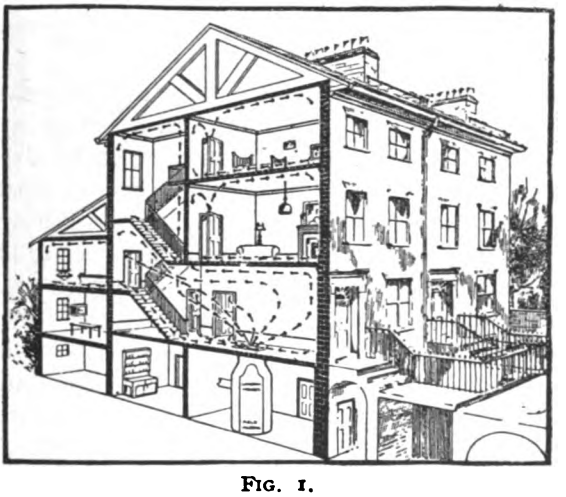

FIG. 1.

To maintain the circulation of the air, a second casing is added outside the hot-air chamber, forming a chamber for cold air which is connected with the outside of the grating through which the warm air passes. The two compartments are connected at the bottom.

* See *Domestic Fuel Consumption*, by Professor A. H. Barker, and *The Smokeless City*, by E. D. Simon and Marion Fitzgerald.

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As soon as the fire is lit, the air in the inner compartment is warmed and rises through the grating, and is replaced by cold air drawn from the outer compartment and, therefore, from the air of the house. This movement is continuous so long as the fire is burning. Of the total energy obtainable from the fuel it is estimated that two-thirds is used in raising the temperature of the air and one-third is used in expanding and so circulating the air.

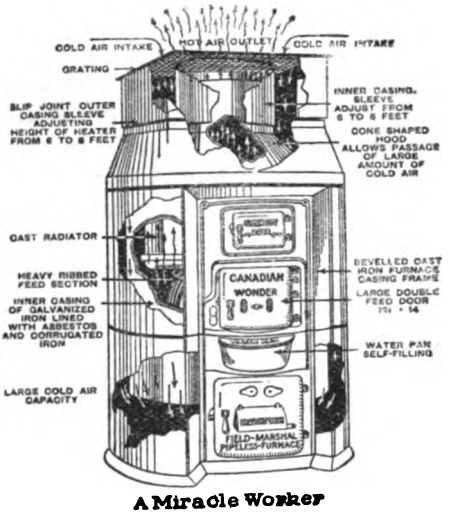
COLD AIR INTAKE
HOT AIR OUTLET
COLD AIR INTAKE
GRATING
SLIP JOINT OUTER CASING SLEEVE ADJUSTING HEIGHT OF HEATER FROM 6 TO 8 FEET
INNER CASING SLEEVE ADJUST FROM 6 TO 8 FEET
CONE SHAPED HOOD ALLOWS PASSAGE OF LARGE AMOUNT OF COLD AIR
CAST RADIATOR
HEAVY RIBBED FEED SECTION
INNER CASING OF GALVANIZED IRON LINED WITH ASBESTOS AND CORRUGATED IRON
LARGE COLD AIR CAPACITY
BEVELLED CAST IRON FURNACE CASING FRAME
LARGE DOUBLE FEED DOOR
WATER PAN SELF-FILLING
CANADIAN WONDER
FIELD-MARSHAL PIPELESS-FURNACE
A Miracle Worker

FIG. 2.

In the case of a building without a basement, the same effect is produced by omitting the outer casing and drawing in cold air at the bottom of the inner casing, discharging warm air about 8 ft. above the floor. In a simple building like a workshop a heater of this pattern could be stood on the floor of the shop, but for a house it is best to place the heater behind a wall, drawing cold air through a grating in the wall at floor level, and discharging warm air through a grating in the wall just under the ceiling.

With either pattern the only constructional details which have to be attended to are (1) a stone or concrete foundation for the heater; (2) protection by uralite or some non-conducting material round the grating if it passes through a wooden floor; (3) the connection to the flue. In an ordinary house with a cellar and suitable flue the fixing of the heater can be done by a couple of men in about 12 hours.

Now considering heating only, it will at once be evident that this system should be very economical as there is no unnecessary wasting of heat. Much of the heat from the air is used in warming the walls, floors and ceilings and the furniture of rooms, and as soon as these have received a certain amount of warmth, the general

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temperature of the house is maintained at considerably above the temperature of the outside air. The air drawn into the outer compartment of the heater is thus already partly warmed and a less expenditure of fuel is required to bring it up to our working temperature. Compared with any system where fresh air is drawn from the outside, heated, passed once through the room and then out, the saving of fuel is very considerable.

But it is objected that this saving is effected at the expense of ventilation, as the same air is used over and over again.

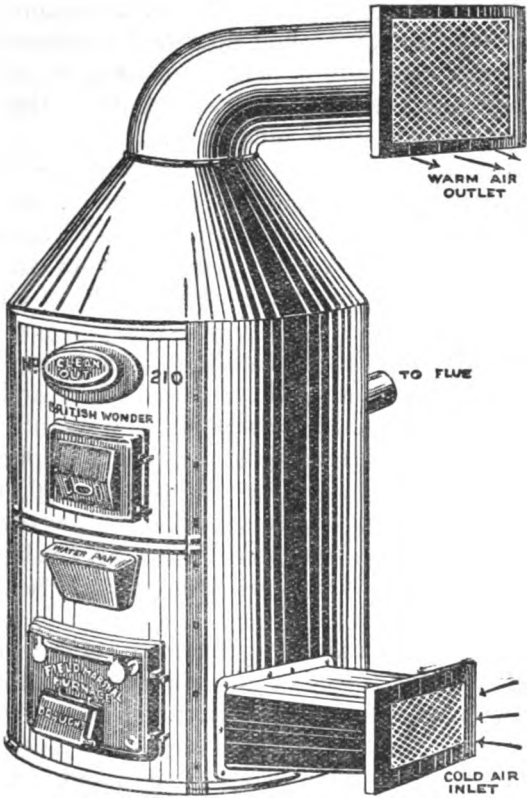

FIG. 3.

Systems of ventilation are often discussed as if it were possible to remove the whole of the air in a room and replace it by an entirely fresh supply. In practice this is never the case, however complicated may be the system of ventilation adopted. What actually happens is that the incoming air mixes with the air in the room and *dilutes* it, while an equal volume which may, however, contain much good air, escapes through ventilators, chinks, etc. The process is the same as if we try to change the contents of a pail of dirty water by pouring clean water in at one side and allowing

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an overflow at the other. The contents of the pail will become much cleaner in time, but some trace of the original dirt will always remain. At best, therefore, a system of ventilation is one of *dilution*, not one of change of air.

Now Pipeless Central Heating applies the same principle by encouraging the mixing of the air throughout the house. It is evident that, while several people confined in one small room may seriously vitiate the air, they would have little or no effect on the air of a house as a whole. At the same time as the heater is mixing the air of a house there is a continual escape of warm air through chinks, or up the chimneys of fireplaces, and also a continual ingress of cold air from the outside, round door and window openings and through ventilating openings. The combination of this with continual movement produces an atmosphere inside the house which is quite pleasant and absolutely innocuous.

We have seen above that one of the ingredients of comfort is sufficient moisture in the air, and this is provided for by a pan of water placed in the hot-air compartment of the heater near the furnace. The heat causes a slow evaporation of the water and so produces a sufficient proportion of moisture in the ascending warm-air current.

It will be evident that there are certain special cases where some modification may be necessary. For instance, in churches, theatres or cinemas where there is a large number of occupants, the heating effect would be quite adequate while the hall is empty, but would not be satisfactory when in use. In such cases, it might be advisable to connect the outer casing of the heater with the outer air by a duct so proportioned that about one-third of the fresh air supply is drawn from outside. This duct should be closed by a damper when the hall is not occupied.

Again, in a large building the movement of air produced by expansion may not be sufficient to ensure circulation. In such cases the circulation can be helped by a fan so placed as to increase the movement of air through the heater.

The above is only an outline of the system and any attempt at calculation has been omitted. No doubt, in time a body of literature will be built up round the system, but at present the new art is in its infancy.

Some figures can, however, be given about fuel consumption. The heaters, as designed, will burn coke or coal, or can be adapted for wood or gas, but the best fuel is coke, as it is cheap and easily obtained and is smokeless, an important consideration in a town.

The consumption will, of course, vary with the size of the heater, but for an ordinary ten-roomed house using a No. 2 heater the daily consumption would be about 40 lbs., or about 8d. a day with coke at 40s. a ton.

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It seems worth considering shortly how this system will affect the detailed arrangement of our houses. At present the arrangements of any room are conditioned by the necessity of avoiding cross draughts, so that the relative positions of door, windows and fireplace give a problem of some complexity. With an efficient system of central heating fireplaces are unnecessary, or, at best, are luxuries.

An open fire is undoubtedly a most comforting form of heating, and if the expense is not prohibitive, the use of a fire adds to the circulation of air and is in no way antagonistic to pipeless heating. But in many rooms no fire is required from year's end to year's end. It should, therefore, be possible to dispense with fireplaces and chimneys altogether except, perhaps, in the largest sitting-room and one bedroom. A very pleasant form of auxiliary heat, which would combine well with pipeless central heating, is a portable electric stove which could be used to keep individual rooms above the temperature of the rest of the house. This would be especially useful in cases of sickness.

Then again doors become largely redundant, except where privacy is required, as in bedrooms or a private study. In the United States it is a common practice to open all the sitting-rooms through one another, with archways instead of doors and curtains or screens to give some measure of privacy. Heavy portières over doors are, of course, unnecessary, or even harmful, while window curtains will be used mainly to keep out light, and not to control draughts Coupled with the fact that the abolition of fires will reduce dust and dirt, the whole house will thus be lighter and cleaner.

Of course, bedrooms must retain doors, and doors must also be used to shut off the kitchen premises.

Many people, seeing the system for the first time, ask " Must the doors be always kept open ? " and this is generally answered by the question, " Why must doors be kept shut ? " If special attention is paid to this point, it will be found that in summer-time, when the air is warm, doors are generally left open, so that the fetish of the shut door, which was one of the plagues of our childhood, is really due to a wish to exclude draughts. As stated, the United States dispense with doors in many cases, while the popularity of the lounge-halls in modern English houses show that the same principle is acceptable to the British. In the case of bedrooms, the doors are usually open for several hours every morning for domestic reasons and for ventilation. This amount of opening would be quite sufficient to allow of the room getting filled with warm air; once this is effected the normal leakage round and under doors should be quite sufficient.

In cases like hotel rooms or officers' messes, where doors must be kept closed for reasons of security, it would probably be necessary to add a ventilator over the door. This ventilator might be fitted

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with movable louvres controlled by the occupant, and may become a normal fitting in all rooms in which fireplaces are omitted.

Windows in a house will still fulfil their primary function of admitting light; they can be opened with discretion as required. Each housewife will soon find the best combination of heater, open window and open door, which gives the most comfortable temperature.

To conserve heat in exposed situations, windows can be doubled or double-glazed.

It is evident that these principles can be applied to many military buildings. The ordinary barrack room is very badly warmed by open fires and there is little control of fuel consumption. The use of one heater for each block, with the draught doors of the heater controlled by a simple switch in a serjeant's bunk, and the heater itself in a locked room in the basement would ensure perfect control. The only constructional details required would be to fix swing doors (double, if possible) at the entrance, a few ventilating openings high up in each barrack room to ensure sufficient movement of air at night, and possibly to add gratings over the door of each room for the admission of warm air. The cold air will escape easily enough under the door.

In a military recreation establishment, this form of heating should be ideal, especially if the establishment is designed round one central large room in which the grating is placed.

Officers' and Serjeants' Messes can be warmed by a heater under the main passage. Gymnasium and Drill Halls could be warmed by a single casing heater placed in a corner of the room.

Single married-quarters are perhaps rather small to have a heater in each, but a block of married-quarters, with two or more floors, would be well warmed by a heater on each staircase, provided the latter is enclosed and fitted with swing entrance-door and a grating is placed over the door of each quarter.

The above are only suggestions, but probably sufficient has been stated to interest readers. If so, I should be glad to show any enquirers our heater in actual use, and to discuss the detailed application of our principles of working to individual buildings.

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THE RAILWAY DISTRICT AS A BUSINESS ORGANIZATION.

A Lecture delivered to Junior Officers of the North Western Railway of India at Lahore in November, 1922.

By CAPTAIN G. WALTON, O.B.E., R.E. (*Lahore District Traffic Superintendent.*)

IT may perhaps be said that the title of this lecture is a self-evident truth, not worth further discussion. But this railway covers such an immense field, not only in track, number of men employed and so on, but also in the amount of business done, that we have to get down to the district unit to analyse and compare results and to get our ideas in proper focus. My object, therefore, is briefly this : To point out how a united effort by officers and men of all departments of any one district (which is in many respects a complete railway in miniature) will conduce to the real aim and purpose of a railway—that is, efficient and economical transportation in that district of the railway at a reasonable profit to the owners of the railway, and to the satisfaction of the public. At the same time, every detail of the work of district and assistant officers and senior subordinates of all departments, in office or on inspection—whether it be seeing that a wagon is riveted up to protect its contents from theft, testing a man for his fitness for a job, arranging water and food facilities for the public, checking control graphs, turning out coaching stock from shops, getting an urgent repair to stock or permanent-way done quickly, keeping station fencing in order, avoiding engineering restrictions and so on —must focus on to the district percentage of working expenses to receipts, and to the reputation of the district among the travelling and commercial public.

The business of a railway can be divided into two parts—soliciting traffic, and then moving it—which correspond quite closely to the customary separation of an industrial enterprise or shop into the selling end and the manufacturing end. The railway manufactures one commodity only, transportation, and sells it to passengers, merchants, shippers, the post office and so forth. The amount sold will depend upon (*a*) demand ; (*b*) amount of competition ; (*c*) quality of the commodity offered ; and (*d*) price at which the commodity is offered for sale. The main distinction between the manu-

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facturing done by a railway and that done by a cotton mill or a chemist's shop, from the standpoint of management and control, lies in the fact that the plant and equipment of a railway are spread over a tremendous physical stretch of country, while most of the work is done by transportation units, which are constantly moving from place to place so that they cannot be continuously supervised. It is not possible for the head officer of a railway actually to see on inspection more than a very small percentage of his railway's traffic moved. Therefore, since the eye of the head of the concern is necessarily limited in its physical vision, other means of control for the property must be provided.

With the gradual growth of railways, departments were created, sub-divided and again sub-divided; officers found that they must have more and more elaborate reports to guide them; the day of the specialist arrived, and the science of transportation was taken up in earnest. But, with this rapid development along special lines, it has become more and more difficult to obtain a true perspective. The department officer may work for his department alone, losing sight of the broader interest of the shareholder (or the Government in the case of State Railways), and finding it difficult to obtain any very clear view of the relation of his work to that of other departments.

It has been mentioned by Mr. Byers, in his *Economics of Railway Operation*, that the principal rule of organization is to provide a supreme authority at all points where action must be taken. The question in any organization is: At what point should this centralizing authority appear? There are two extremes. If the local officials are entirely unrestricted in their actions, harmony of action throughout the system as a whole becomes impossible. If, on the other hand, all power of initiative is placed in the hands of one central authority, he is so flooded with detail as to cause great delay. Two radically different modes of organization have been worked out, and are generally known as the divisional and departmental. The divisional system, adopted in America, and to a certain extent on the Continent and in England, is arranged on the basis of territorial division of the property as a whole, giving to each territory a more or less complete organization under a single officer. The departmental system, on the contrary, operates on the basis of territorially dividing each department, placing an officer in charge of each district and making him directly responsible to the head of that department. On the broad-gauge portion of the North Western Railway the organization is, as you know, departmental, and the actual unit basis of the railway organization is the district. It is my object to try and show how we should work with this organization to obtain the advantages of the divisional organization in general economy and efficiency.

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In certain traffic districts at present we have, under one officer, Assistant Traffic Superintendents in charge of Commercial, Passenger, Transportation and Establishment matters respectively. The other branches of work in a district which have to co-ordinate with the above to form a homogeneous district are locomotive running, carriage and wagon, engineering, police and accounts. It has been mentioned to me that a district is, perhaps, a small unit; but in order that we should get a true sense of proportion, it may here be noted that several districts on this railway are of about the same length as and earn more than several separate small railways in Great Britain and other parts of the world, which are equipped with a chairman and board of directors, general manager and heads of departments. The Lahore District, for instance, alone equals the entire Great North of Scotland Railway, and will shortly equal the Highland Railway in mileage and earnings, and is well ahead of concerns like the Gold Coast Railway or the Ottoman Smyrna Railway. Before, however, the district unit can be considered a real one, the district of the various departments must be coterminous, and this is, I believe, gradually being done in connection with the installation of telephone control circles radiating from district headquarters. Thus we have got down to a manageable unit for detailed control within that unit, and for comparison of efficiency and economy from year to year, and also with other district units by the Agent and heads of departments.

To give some idea of the duties of a Station-Master, and how he is watched, a list of the efficiency points that traffic officers look into on their inspections is given in Appendix A. In addition, adequate statistics are required to enable district officers to see how the work which they are doing compares with work done in other districts, as there are many operating efficiency factors, such as average loads of trains or wagons and so on that cannot be expressed in rupees, annas and pies in the balance sheet, but must be compared with previous figures and with other districts. Statistics are necessary also to see that districts are not retrograding, but improving, in efficiency year by year. It is possible that district officers, in ignorance of what their neighbours have accomplished, would lag far behind the achievement which they might reach were they stimulated by knowledge of the results attained elsewhere. The general tendency, however, is to try and express as many statistics as possible in terms of money as in this workaday world the comparison in a man's mind with the rupees, annas and pies of his monthly salary conveys more to him than juggling with figures of net ton miles per engine hour and so on. As an example the American railways have calculated, and told their staff, that in July, 1922, it was necessary to haul a ton of goods 68,996 miles to earn a sum sufficient to pay the annual wages of one permanent-way man, and 124,646 miles

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to pay those of a clerk. Tell a driver or a station-master how a few more pounds per mile in coal consumption, or a few more hours per week of a shunting engine, compares with his monthly salary, and he will sit up and take notice, or he should be made to. Railway control, through statistics, might be defined as the process of finding the unit in each operation, of seeing to it that these units are rigid, that they are collected and reported accurately, promptly and economically, and then of taking the necessary measures to correct the defects which they indicate. Statistics are the clinical thermometer of industry, but don't worry the invalid by taking his temperature too often, and then pulling a long face over the result without using your best skill as a doctor to improve his health. Sir Sam Fay, in his presidential address to the Institute of Transport, uttered a word of warning about statistics, when he said that an average is not always a fact, and can easily become a disease, and that the accuracy and legitimate use to which any figures, costing time and money to compile, are put should be carefully analysed by men who are engaged in actualities before they are ordered, or the red-tape-worm will, in the course of time, have crowds of clerks administering to his growth and the extension of his clogging power.

It is suggested that the following graphs (which show statistics in a clear way) would give a District Traffic Superintendent a complete summary of the financial and efficient working of his district month by month :—

(*a*) *Passenger train running*—

Percentage of trains arriving right time. (These can be got out weekly.)
Percentage of trains not losing time.

(*b*) *Goods train loading*—

Average net starting wagon load, varying with commodity.
Average net train load on each engine run.

(*c*) *Goods operating*—

Average speed of goods trains on each engine run.
Net ton miles per engine hour.
Shunting engine miles per 100 train miles.

(*d*) *Earnings*—

Number of passengers carried : number of passenger miles.
Gross coaching receipts.
Number of tons carried : number of ton miles.
Gross goods receipts.
Total train mileage.
Total receipts.
Receipts per train mile.

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(*e*) *Expenditure*—

Expense under each budget head, with a line showing sanction for each.
Total working expenses.
Percentage of working expenses to receipts.

(*f*) *Commercial expenditure*—

Total outstandings at large stations.
Total claims paid.

(*g*) *Miscellaneous*—

Number of accidents, by classes.
Number of fines, punishments and reductions.
Amount collected on excess fares and undercharges.
Number of employees.

The important graphs of gross receipts, percentage of working expenses to gross receipts and expenditure under each budget head, varying with the department concerned, would probably be found useful by the district officers of departments other than the Traffic Department. Moreover, under the organization in a district where each Assistant Traffic Superintendent is responsible for a particular function—Establishment, Transportation, Commercial or Passengers —an Assistant Traffic Superintendent would, no doubt, like to keep up graphs of his own particular subject so as to be prepared to justify some adverse trend in the graph, and he would also consider some graphs useful for himself to watch more carefully the work of his Inspectors, Controllers, Station-Masters or Goods Supervisors.

The Acworth Railway Committee pointed out that economical railway management cannot be ensured without a proper system of railway cost accounting, not merely to say whether expenditure incurred has been duly authorized, or receipts duly accounted for (which is the business of an outside firm of accountants), but to say whether expenditure has been wisely incurred, whether retrenchment of habitual expenditure is possible under any one head, whether new expenditure under another is proving profitable, whether a larger expenditure would be likely to be fruitful, or whether by arrangement and a little better administration a certain difficulty cannot be met without spending other people's money, and so on. The last point is a particularly important one in this country. Would requisitions for costly material or extra establishment be signed so gaily if an officer personally, as owner of the business, had to furnish the cash, instead of signing his name and spending another man's money? Cost accounting enables every commercial concern to get in closer touch with the operation of its works and to keep a very close control over expenditure. By comparing wage costs at

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different periods, the danger of overstaffing, which frequently occurs in large districts or works, can be readily detected. Similarly a check is obtained on any waste of materials that may be occurring. This not only applies to the materials of manufacture, but also to such items as gas, water, fuel, oil, etc. Overhead charges should be frequently revised, as any changes in the methods of any department will make a considerable difference to this item. From this information, profitless lines of business may be detected, as also the relative value of each department to the business as a whole. It is, however, necessary that the cost accountant should present his information in a lucid and clear form as up to date as possible. In England they have gone so far as to say that many labour disputes can be avoided by negotiations on wage rates taking place on the basis of the cost and selling price of the commodity produced as the only equitable means of deciding such a matter. With a simple district balance sheet and summary of comparative statistics, and periodical study of them at the monthly district officers' meetings and at the Agent's annual inspection, where they might be presented in a similar manner to the annual progress report submitted by a board of directors at the annual shareholders' meeting, it should be possible for district officers to improve the State property entrusted to their management, and thus to carry more traffic, even with existing facilities, and largely increase State profits—a matter of considerable interest to every taxpayer.

Every department, except the Traffic Department, is almost entirely a spending department, while the check of the correct receipts of revenue is done by the Audit Department, so a district balance sheet will bring home to district and assistant officers of all departments the relation between the expenditure and revenue for their district, and the necessity of combining to keep down the district percentage of working expenses to receipts, and to bring their district above all the other districts of the railway. This balance sheet is actually made out by the Audit Department, and, when these balance-sheets are prepared for coterminous districts and at a shorter interval after the period under review, their use will be much enhanced. The balance can in the same way be extended to stations so that comparisons may be made between stations of percentage of cost of staff or stores to earnings and so on. This will also bring out the efficiency or otherwise of different members of the staff, Booking, Parcels, Goods Clerks, etc. The book of Operating Statistics prepared by the Audit Department is about to be brought still more up to modern practice and gives you the efficiency facts, which supplement the financial facts in the balance sheets.

In analysing the balance sheet, it is necessary to obtain a proper sense of the relative importance of the different items making up the operating expenses.

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The cost of the North Western Railway in 1920–21, in crores of rupees was :—

Establishment	4·61	or 42·6 per cent of whole
Maintenance of property	2·63	expenditure.
Fuel	1·34	
Other expenses	2·24	
	10·82	

It is therefore clear that the greatest scope for economy is in establishment.

Analysed by departments, the results for the North Western Railway in 1920–21 were :—

	Percentage working expenditure to gross earnings.	Percentage of total expenditure.
Maintaining the plant—		
Table A—Engineering Department ...	13·87	19·82
,, B—Locomotive Department ...	26·48	34·62
,, C—Carriage Department ...	7·86	12·12
Doing the work—		
Table D—Traffic Department ...	12·71	17·60
Maintaining the organization—		
Table E—Agency and Audit, Medical and Police Department ...	4·60	8·31
,, G—Provident Fund, Law, etc.	3·83	7·53
TOTAL ...	69·35	100·00

while the percentage of net earnings on total capital or the dividend was 4·51. This compares very unfavourably with 1916–17, when the percentage of working expenditure to earnings was 45·54, and the percentage of net earnings on total capital was 7·21. So far as the Engineering Department is concerned, the primary object is to make possible the transportation, at a profit, of freight and passengers. The expenditure will, therefore, be made principally for the following reasons :—

(*a*) to permit the safe, and also comfortable, passage of trains at usual speeds ;
(*b*) to improve the appearance of the property ; and
(*c*) to reduce the cost of future maintenance.

The high cost of the Locomotive Department is due very greatly to the cost of fuel, and it is for this reason—especially on this railway, which is at such a distance from the coal-fields—that very careful check on fuel has to be made by statistics of efficiency of operation, and, wherever possible, statistics should be translated into cost of

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service as people take more interest in rupees, annas and pies. One can thus examine in turn each head and sub-head of expenditure, and see how economies can be made without reducing efficiency. The various balance sheet headings of expenditure for the Traffic Department in 1920–21 compared with gross earnings were as follows :—

D I (*a*)	General Superintendence ...	1·33% or 6th out of 10 leading railways of India.	
(*b*)	Station staff	6·88% or 9th	do.
(*c*)	Train staff	1·81% or 8th	do.
D II	Fuel, light and water ...	1·84% or 8th	do.
D III	Clothing	0·59% or 10th	do.
D IV	Printing, stationery and tickets	0·26% or 1st	do.
		12·71% or 9th out of 10 railways.	

The Madras and Southern Mahratta Railway is first with only 7·67 per cent.

It will thus be seen that the greatest scope for economy lies in (*a*) station staff and (*b*) uniform ; though we are worse than most other railways under each head except printing and stationery. It must, however, be remembered that the North Western Railway has a considerable proportion of its mileage built for military and strategical reasons rather than purely commercial. Just as from the Administration Report comparisons can be made with other railways, from the balance sheet of the less unwieldy unit—the district—is obtained the healthy rivalry between districts, and not between departments. In general terms, therefore, we may say that the expenditure on railways divides itself into that on establishment and that on material. The figures for German State railways are interesting in this respect. In 1913, before the war, expenditure on material amounted to 40 per cent., whereas the expenditure on establishment amounted to 60 per cent. of the total expenses of the railways. In 1919, owing to the overstaffing of railways, the 8-hours' day and the depreciation of railway plant, the above proportions had changed to 30 per cent. material and 70 per cent. establishment. Then, when the Government undertook to put the railway plant in order, the proportions in 1922 came to 53 per cent. material and 47 per cent. establishment.

On the other side of the account, every effort has to be made by each department to increase the revenue, and departments other than the revenue-earning one can help considerably in this vitally important matter. There are two general methods of inducing people to use the railway more frequently : one is the reduction of fares and rates, the other is the improvement of the services. Before even considering the former, we have to get our percentage of working

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expenses to gross receipts very much better than at present, but all departments can work towards the improvement of the service, passenger, parcels and goods. Formerly the Engineering, Locomotive and Carriage Departments and the transportation branch of the Traffic Department greatly overshadowed the commercial and passenger branches of the Traffic Department, but, with the growth in volume and variety of traffic, with the extension of services and with the ever-increasing importance of developing and enforcing rate policies that both harmonize with changing economic conditions and yield the railway profitable revenues from its many services, the position of the commercial and passenger branches of the Traffic Department in the general organization of the railway has become as prominent as that of any other department. To sell our commodity, we have to give every reasonable satisfaction to our customers, even though we may be a State railway and without a competitor for the traffic. Every engine and every carriage is a travelling advertisement of our business, every serious accident a blot on our reputation, every late train, whether due to engineering restrictions, crossing other trains or what not, a reflection on the undertaking, while much depends on the comfort of passenger carriages, and courteous treatment. For goods and parcels traffic, our reputation depends mainly on the time required for transportation and the safety of the goods while in our possession, which latter is, however, a most important financial matter in the saving of claims in our debit account. One of the greatest leakages in revenue is in the matter of fraudulent travelling, and reasonable expenditure is justifiable to bring in the large amount of revenue lost yearly through this cause.

To show the rate at which railway traffic in India is rising, goods earnings on all railways have more than doubled in 20 years. Passengers in 20 years have trebled in number, and quadrupled in earnings, showing increased prosperity and importance in railway policy. Nevertheless, goods traffic is still the more important item from the standpoint of revenue, being 52 per cent. of the total revenue on all Indian railways in 1920–21, passenger revenue being 44 per cent. and miscellaneous 4 per cent. The earnings per mile per week show the development in material prosperity of the areas served in India :—

			Rs.
1890	...	...	243
1900	...	...	245
1910	...	...	306
1920-21	...	...	478

The constant effort of every railway is to secure the volume of traffic, and to maintain rates and fares that will jointly yield a maximum net profit. Net revenues are the resultant of three factors —traffic, rates and transportation expenses. The transportation

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branch seeks to operate the district as economically and efficiently as possible; the commercial branch endeavours to keep revenues at a maximum by establishing rates and fares that will enable traffic to move in large and increasing volume. The rate and fare policy that yields largest net returns in the long run is not to make charges as high as they might be put at any given time, but, while keeping them high enough to be profitable, to maintain them at a level below the maximum to guarantee the unhampered growth of industry and travel, and thus of traffic. The operating statistics show, for instance, the effect of the increase of rates on the number and class of passengers and the gross earnings. In July, 1922, on the Lahore District, although there was a decrease compared with July, 1921, of 1,240 first class, 20,276 second class and 33,045 intermediate class passengers, there was a net increase of 151,250 passengers in all forwarded and received owing to the continuous increase of third class passengers. Incidentally it may be mentioned that 92 per cent. of the passenger traffic on the Lahore District is third class, and the above figures give us an indication of the urgent need for third class stock. The total earnings of the Lahore District have risen from Rs. 14·4 lakhs in July 1921 to Rs. 18 lakhs in July 1922—the earnings are thus about £4,000 a day, and the expenditure about £2,800 a day; and this expenditure is gradually decreasing as a result of the Economy Campaign.

From the balance sheet and statistics, recommendations can then be made regarding the extent to which expenditure for maintenance and betterment may be safely increased, or to which they must be reduced for the ensuing period. The development of traffic, both for passengers and goods, is dealt with very much more intensively in England and America, and the fact that English railways, after being grouped, continue their system of advertising, traffic canvassers, agricultural trains and so on, shows that this matter does not neces sarily depend on the keenness of competition. General Magniac, President of this year's Indian Railway Conference, remarked on the necessity of publicity to bring to the notice of the public the good work that the railways do, and the efforts being made to improve matters. The American railways contend that getting a share of traffic that already exists is an important part of a railway traffic officer's duty, but making business that does not exist is the greatest end they should strive for. So far as passengers are concerned, we cannot provide sufficient third class stock at present to carry the existing traffic, but reduced first and second class excursion fares for Christmas, etc., will help to fill the first and second class as the number of these passengers had fallen after the general increase of passenger fares. Indian third class rates are still the cheapest in the world. The Traffic Department is the one which represents the railway in its dealings with its customers, passengers and

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merchants, and it is from the latter that the larger part of its revenues is obtained. The Head Office Commercial Department makes thousands of rates in which tens of thousands of persons have a vital interest. Upon the rates charged by the railway, and on the services we give on the district, depend the success or failure and adversity of numbers of business enterprises. To satisfy the reasonable demands of the public, to convince other business organizations of the unwisdom of unreasonable or impracticable requests, to give the staff a responsible standard of comfort, reasonable hours, to enforce charges that are profitable to the railway, and generally to establish and maintain harmonious relations between the railway and the men and communities it serves, these are the difficult tasks of traffic officers and men, and they cannot possibly carry them out without the whole-hearted co-operation of officers and men of all other departments. To quote again from Sir Sam Fay's address, the public are always ready to lend an ear to charges of inefficient management, and he emphasized the necessity, now that the tentacles of transport stretch to every factory, office and home, of having the district officer in close daily touch with the point of the tentacles. Then, having secured the best results obtainable in the operation of a district as it exists, it becomes desirable to consider in what way the net earnings can be increased by additional expenditure for betterments in the way of heavier track, more powerful engines, quicker yard work, reduced road delays, electrification and so on. One of the points necessary to hold constantly in mind is the securing of evenly-balanced "capacity of line" facilities, as yard and track facilities must keep pace with engines, bridges and shops. This has been clearly brought out in the report of the Agent's Committee regarding the improvement of facilities between Lahore and Rawalpindi.

Balance sheets and statistics are not, however, going to run a business concern. They are the guides which will indicate to a certain extent what is happening. The one and only way to ensure that things are moving with that ease and simplicity which usually characterize competence in its highest expressions, and that the district balance sheet and statistics will improve each month, is by constant personal inspection by officers of the details of working, as well as the broader aspects of district working. "Trifles make perfection, but perfection is no trifle."

APPENDIX A.

(1) Monthly pay of staff under each branch—coaching, parcels and goods.

(2) Other monthly expenditure incurred by station in stores, fuel, stationery, etc.

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(3) Money receipts per month in each branch—coaching, parcels and goods.

(4) Number of passengers booked per month, number of maunds of parcels and luggage booked per month and number of maunds of goods booked per month.

(5) Duty hours.

(6) Number of invoices and parcels way-bills dealt with.

(7) Courtesy, general conduct and smart appearance of staff, knowledge of rules by staff.

(8) Platform, clock, telephone, telegraph and line clear service and traffic regulation: posting of station working rules.

(9) Time made up at the station by mail, passenger, goods and other trains.

(10) Movement, loading and unloading of rolling-stock, good average loads to wagons.

(11) Booking-office service.

(12) Tidy and clean appearance of station premises, gardens and approach roads.

(13) Posting of time and fare tables and notices.

(14) Dealing with signals, train, telegraph or other failures, avoidance of accidents.

(15) Suggestions for improvement of traffic earnings.

(16) Lighting and upkeep of all lights, supervision of bookstalls and other contractors, handling of goods.

(17) Prevention of trespassing, keeping station entrance and exit clear of loafers, etc.

(18) Expeditious opening of level-crossing gates to road traffic.

(19) Working of vendors and watermen.

(20) Upkeep of fire- and theft-protection arrangements.

(21) Upkeep of goods and parcels registers, and absence of complaints from merchants.

(22) Disposal of unclaimed property and goods and parcels outstandings.

(23) Marking of goods, and riveting and labelling of wagons.

(24) Amount collected on excess fares, and on undercharges for luggage, parcels and goods.

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A SUGGESTION FOR ANTI-AIRCRAFT GUNFIRE.

By LIEUT.-COLONEL D. M. F. HOYSTED, D.S.O., R.E.

HAVE you ever watched a large fire in London and noticed the wonderful accuracy with which the firemen can guide the powerful jets so as to reach the exact spot which they wish to strike with the water-stream?

The men in charge of the nozzles are chosen for their size and strength, in order to be able to hold them steadily so as to ensure accuracy of aim. Obviously they reach their target by very quick correction of aim (elevation and direction), which they are easily able to apply because the curve of the water-jet is continuous and they can see where it is falling at any given instant. As they increase the elevation, the point of impact of the jet with the target rises to correspond, and the fireman can stop elevating when he sees that the water-stream is washing over the object he wishes to strike.

During the war, how many times must the casual observer of an anti-aircraft artillery attack on a Boche machine in France have been struck with bewilderment at the fact that it was possible for the burst of shells to maintain such an immense error of distance from the target.

It is true that to be successful as an anti-aircraft gunner is extraordinarily difficult, and that the difficulties hardly appear till one begins to study the theory of aircraft flight with the hope of finding some very weak point on which to base an easier method of attack.

The airman can move instantaneously in three dimensions while travelling at any speed up to a hundred yards a second. His height and speed are unknown, the only obvious factor being his direction at any given instant. Even this factor is disturbed by the knowledge that he can alter it with great rapidity. The time of flight of the shell may be twenty seconds, during which period the machine may have moved over a mile.

There are some wonderfully clever instruments by which the height and fuze range may be determined quickly, but when one realizes that the machine, if passing straight over the gun at 150 or 200 miles an hour, may only be within range for a couple of minutes while coming and another couple of minutes while going, the troubles of the gunner's life may be more easily imagined. Besides which, only a very small portion of the actual target is vulnerable, and only the vulnerable parts count at this game in which the result of a

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shot is either a hit or a miss, and a splinter may pass through wings, tail or fuselage without recording a counting hit.

The method of attack at present in vogue is to find the height and consequent fuze range before the hostile machine is within fire range, if—and this one is a very big "if"—it is a clear day, *and* it is spotted in good time, *and* there are no other hostile distractions. A burst of five shells is fired: time taken, about fifteen seconds. As soon as the bursts can be observed, correction is made for lateral and horizontal deflection and another five sent on their way. If the initial computations are good and the gun is well handled, the second correction of deflections should give the best results obtainable. The firing record would be approximately as follows:—

First five rounds	15	seconds
Time of flight (say)	12	,,
Observation and correction	5	,,
Correcting fuze settings for next burst ...	5	,,
Second burst	15	,,
Time of flight (say)	8	,,
Observation and correction	5	,,
Correcting fuze settings for next burst ...	5	,,
Third burst	15	,,
Time of flight (say)	5	,,
Total ...	90	,,

The corrections must be judged and applied with lightning speed, as the essence of the whole operation is time—to get in the greatest number of carefully aimed rounds that is possible, in the period during which the target is within effective range. But these corrections can only be based on conditions noted ten seconds before the shells are fired, and are ancient history by the time the shells reach their positions of burst.

When speaking to a gunner who had a large percentage of successes compared to others, the writer was told that the study of the psychology of the enemy pilot played a large part in the estimation of his correction for deflection, because of the great difficulty of obtaining and applying them correctly when mechanical means were used. On one occasion, when he was firing at a German Intelligence patrol machine, he realized that the pilot always made his turn in the same direction at more or less the same point. So, instead of following him up on his line of flight as before, he laid for him at the turn and brought him down.

The chief reason why it is necessary, at present, to fire sets of five rounds and observe the bursts for correction of deflections, is that otherwise so much ammunition would be used up that it

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would be impossible, at present, to ensure the continuity of the supply. But this difficulty is obviously governed by relative values, which are subject to fluctuation. A few years before the war, while the writer was in Egypt, officers were invited to write an essay on their opinion for an ideal infantry company. The writer's suggestion was as under :—

Riflemen (with bayonets)	100
Maxims and crews	5
No. of Companies to the Battalion	6

The adverse criticism made by the General Staff was to the effect that the number of machine-guns was beyond all possible requirements and that the ammunition supply would be impossible. Yet how many machine-guns, exclusive of Lewis guns, did the end of the Great War find affiliated to a battalion?

Even supposing that the supply of ammunition for an anti-aircraft gun must not be increased beyond the present establishment, would the gunner not have a better chance of bringing down his target if it were possible to apply his correction in the same way as the fireman makes them when using his hose? Supposing the gun were of the nature of a 3-in. automatic feed machine-gun, firing one shell every two seconds, the number of rounds fired per minute would be thirty. But, and it is with this " but " that the value would be noticed, the chain of bursts would be definite and would approach the regularity of the water-stream. So that the gunner could apply his correction much more quickly and automatically, as the corrector would be the gun-commander, who would be independent of section officer and all instruments as soon as he found he was near his target. There would be more chance of obtaining a hit in this way with sixty rounds in two minutes than there would be with sixty rounds spread irregularly over six minutes.

Of course, the comparison of the shell and the jet fails to a certain extent, because the latter is directed at a large and solid object and its efficacy does not depend upon the correct time of flight. But it should be quite possible to apply correction for fuze range while the shells are held in their belt or other feed arrangement. So that, taking an average time of flight of ten seconds, the gun-commander and setters should be able to apply the necessary fuze correction to, say, the tenth and subsequent shells, while making sure of correct alignment with all. The ease and certainty of the correction would be much enhanced if every fifth projectile in the belt were a tracer shell.

There would be great difficulties in the design of an automatic gun of the size indicated, though the construction of a 4-inch machine gun for naval use was mooted some years ago in the United States. The maximum weight of shell hitherto fired from a machine gun is only two pounds, while the tendency for efficient anti-aircraft work is to increase the weight even of the present shell.

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LEAVES FROM AN OLD LETTER BOOK.

(*Extracted by* COL. C. W. DAVY, C.M.G., R.E.)

THE source of the following extracts is an old Confidential Letter Book which came to light recently in the R.E. office at Hong Kong. They throw an illuminating side-light on R.E. activities in the early days of the colony and will, I think, be read with interest, especially by those of my brother officers who have served in the Far East.

The first item in the book is dated, 1st April, 1847, and consists of a lengthy report by Lt.-Col. G. Phillpotts, R.E., of a reconnaissance of the fortified river approaches to Canton made in company with Major Aldrich, R.E., between the 28th and 31st March, 1847.

The report is addressed to Major-General D'Aguilar, C.B., the then G.O.C. in China. It is too long to quote *in extenso*, but the opening paragraph will convey the general idea :—

> Sir,—In obedience to your orders of the 27th ulto., to examine the Chinese defences on the river, and to report to you how far I deem it prudent or practicable for you, with the small force under your command, to go up and attack them, with a view of passing up from hence to Canton, with Her Majesty's Plenipotentiary in order to demand redress of certain injuries that have been repeatedly offered to British subjects by the Chinese."

Lt.-Col. Phillpotts summarizes his conclusions as follows :—

> " From what we have thus seen of the present state of the Chinese defences in the river between this port and Canton, we are both of us of opinion that, although there is a very large number of heavy guns mounted on them, you may safely proceed, with every prospect of success, with the Force now under your command and take the most important of them by surprise, spike their guns, blow up their powder magazines, and then pass up to Canton : provided you embark to-night, in H.M. Steam Frigate *Vulture*, the H.E.I.C. steamer *Pluto*, and private armed steamer *Corsair*, get under weigh before daylight, and anchor close to the Anunghoy Forts as early as possible to-morrow morning. Having taken these, it is necessary that you should post on to the other forts and above-mentioned, if possible before the Chinese have time to hear of your movements and make preparations for a vigorous defence.
>
> " During my absence at Canton the powder bags and light ladders which you ordered to be prepared have been made, and the detachment Royal Sappers and Miners have everything ready for this service.
>
> " On arriving at Canton you will find ample accommodation for

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all the troops in the English Factory, which is surrounded on the three land sides by a very high brick wall, and open on the side towards the river to the steamers which may anchor immediately in front of them, so that you will then be quite safe from any force that the Chinese are likely to attempt to bring against you while you remain at Canton.

" In performing this duty I have received great assistance from Major Aldrich, whose previous knowledge of the country, etc., has been very useful to me."

The G.O.C. appears to have lost no time in acting on this report, and the next item in the book consists of a copy of a General After-Order, dated 1st April, 1847. I think this is worth quoting in full, if only to bear witness to the fact that " methods of frightfulness " had then, as now, no place in the conduct of British troops towards non-combatants.

" The Major-General Commanding acquaints the officers and troops under his orders, that they will embark for service, according to the undermentioned detail, to-morrow morning at 3 o'clock the detachment of Royal Artillery and the acting gunners of the 18th Regt., under Lt.-Col. Brereton, C.B., and K.H.

" The Royal Sappers and Miners under Lt.-Col Phillpotts.

" The whole of the 18th (R.I.) Regt., with the exception of 3 subalterns, 12 serjts., 5 drummers and 170 rank and file, including the sick in hospital under Lt.-Col. Cowpers, C.B.

" The 42nd Regt. M.N.I. to the amount of 300 rank and file with the proportion of officers and under Major Fitzgerald.

" Major Fitzgerald will select one captain and a proportion of subalterns to do duty in Victoria.

" The troops will embark with their knapsacks containing :—1 pair of black trousers, 2 pairs of white trousers, 2 shirts, 1 towel, 1 flannel waistcoat, 1 pair of good shoes.

" Hold-all complete.

" Each man to take with him his great coat, the bedding to be folded and prepared for embarkation at 8 o'clock to-night, the white cap covers to be taken into wear. The Major-General congratulates the officers and men he has the honour to command on the opportunity afforded to distinguish themselves in the service of their Sovereign and their country, and he feels the highest possible pride and gratification to find himself at their head.

" He has only one word to add—that is the word Humanity, and abstinence from everything in the shape of plunder or outrage, as regards the defenceless inhabitants, that could sully the character of British soldiers.

" Major Aldrich of the R.E. is appointed to act as Aide-de-Camp to the Major-General Commanding until further orders.

" The detachment at Stanley and Saiwan to be reduced immediately to the following strength :— *Stanley*—1 lieutenant, 1 ensign, 1 assistant surgeon, 2 native officers, 3 havildars, 50 rank and file. *Saiwan*—1 havildar, 2 Naignes and 12 privates.

" The Major-General Commanding depends upon the vigilance and zeal of the captain left in command here, for the preservation of security and order."

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A brief account of these operations will be found in Vol. I. of Porter's *History of the Corps* at the beginning of Chapter XXI.

The book now proceeds with copies of reports from the various O.C.'s detailing, at considerable length, their particular share in the operations, which appear to have met with but little resistance. The spoils of war seem to have been plentiful as evidenced by the following :—

" Return of the iron and brass ordnance taken and spiked by the British Force under the command of Major-General D'Aguilar on 2nd, 3rd and 5th April, 1847.

" Total, 847 iron ordnance, 32 brass ordnance. Grand total, 879.

" Time did not admit of taking the calibres of the guns of their several forts; their bores were found to be of unusually large diameter, some nearly 13 inches, and none under 5 inches. All were mounted upon new garrison carriages, on the English construction, and with iron truck wheels."

It will suffice if I give the report of the C.R.E. ; the others cover much the same ground :—

" Sir,—I have the honour to report to you for the information of the Hon. the Major-General Commanding that in obedience to his directions, conveyed by your letter of the 4th inst., I proceeded on the morning of the 5th inst., at 7 o'clock a.m., accompanied by Major Aldrich and the other officers of Royal Engineers, together with the detachment of Royal Sappers and Miners and a supporting party consisting of the Grenadier Company of the 18th Royal Irish Regt., under Captain Campbell in the boats of H.M.S. *Vulture*, for the purpose of destroying the stone tower or keep within the fort, called the French Folly ; as well as any defensive arrangements that might be found in the Dutch Folly and Rouge Forts, which had been reported to the Major-General on the previous day to have been re-armed and preparing for action

" The French Folly Fort, which is situated about two miles below the city, on the north side of the river, opposite to the western or upper end of Napier's Island, though much smaller than either of the Anunghoy Forts, is far more formidable, inasmuch as, besides standing on a small island that renders it very difficult of access on all sides except by boats, it had a stone tower or keep, 54 ft. by 42 ft. and 24 ft. high, built of very large ashlar, on which twelve guns were mounted that completely commanded the parapet of the large sea battery that surrounds it, and they afforded a heavy plunging fire over this battery, which, if well directed, would prove very destructive to any party advancing to its attack

" The walls of this battery are 8 ft. thick, and 14 ft. high, above the level of the river. There are 24 heavy guns mounted on it, *à fleur d'eau*, from 8 in. to 12 in. in diameter ; which, if properly served, would effectually prevent any vessels from passing up or down the river.

" Over these guns is a *banquette* with loopholes for musketry, the whole forming a very strong defence against any attempt that might be made to take it by assault.

" When this fort was taken under the Major-General's own immediate supervision on the 3rd instant by the party under Major Aldrich, R.E., the guns were all spiked ; but, as the garrison threw

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water on the powder in the magazine before they evacuated it, we had not then the means of blowing it up.

" On approaching the fort on the 5th instant, Major Aldrich landed with the supporting party, and having ascertained that it was in same state as when we left it on the 3rd instant, I directed him to cause the party to extend round the neighbourhood, in order to keep the mob from molesting us; and likewise to drive away the inoffensive inhabitants to such a distance as would prevent their being injured by the explosion.

" Acting on the principle laid down by the Major-General for our guidance on this expedition, not to do anything that would in any manner injure the defenceless inhabitants, nor, indeed, to do any other injury to the forts, etc., on the river, than merely to render them useless for the time being, I considered it desirable only to employ such a quantity of powder as would merely throw down the keep, without destroying the outer walls of the fort, and thus save the people, who reside all round it, from suffering any ill consequences from the explosion.

" I accordingly directed the charge of powder to be limited to 300 lbs. and while the Sappers, under Lieut. Dacosta, R.E., were placing the powder in the magazine and preparing it for explosion, I directed Captain Durnford, R.E. to make as correct a sketch as possible of the fort, etc., in order that he might be able, at his leisure, to prepare a plan of this work for the Major-General showing the effect produced.

" While these preparations were going on, Lieut. Pascoe, Lieut. Coote and Lieut. Durban, R.N., with the pinnace and paddle-box boats of H.M.S. *Vulture*, the former carrying a 12-pounder Corronade, and the two latter a 24-pounder Corronade each, with a detachment of the Royal Marine Artillery, under Lieut. Davis were employed in driving away the numerous boats and junks that were anchored close under the walls of the fort.

" These arrangements being all made, the supporting party withdrew, and re-embarked.

" I left Captain Durnford, R.E. to complete the train, and fire the charge, on a signal to be given, as soon as the boats with the troops had pulled off to a sufficient distance to be out of danger.

" Captain Durnford performed this duty in a most satisfactory manner. A short time after the signal was given for the explosion, he was seen pulling out to the rest of the party in the gig of the *Pluto* and in five minutes afterwards, being the time agreed upon, a low rumbling sound was heard, a large dense mass of black smoke was seen to rise from the fort, and when it had subsided, the keep, with the exception of a portion of the west end wall, was no longer visible.

" On returning to the fort, in order to see the effect produced by this explosion, I found the keep entirely destroyed, not a vestige of it remained standing, except the wall of the west end, which, however, was so much shaken as to render it highly dangerous to pass near it. The large hewn stones which had been used in building it (many of them 8 ft. in length) were overhanging the foundation, ready to fall at any moment. At the same time the walls of the surrounding battery remained uninjured, with the exception of two cracks that had been made on the south side, about 30 ft. apart, between which two of the heavy guns had forced open the doors, by which the embrasures were closed, and their muzzles appeared outside.

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"Having completed this service we visited the Dutch Folly and Rouge Forts. The guns of the latter remained spiked, as they were left by Major Aldrich on the 3rd instant. Twenty guns were found mounted in the Dutch Folly Fort, all of which we spiked, and returned to the British Factory about eleven o'clock a.m."

The next item of interest is a letter, dated 17th June, 1850, from Major Vincent Bircal, R.E., to the Brigade Major at Hong Kong.

It sheds a pathetic light on the terrible mortality which prevailed among the troops in China in those early days.

Sir,—In forwarding my first half-yearly inspection report of the detachment of the 6th Company of R.S. & M. serving at the station, I beg to call your attention to the length of time a portion of the detachment have been kept in this most unhealthy and disagreeable climate.

"The first detachment sent to this station left England in May, 1843, and landed at Hong Kong 34 N.C.O.'s and Privates. Of this number 12 have died here, 14 invalided, leaving 8 men with worn-out and shattered constitutions.

"The second detachment left England, February, 1845, and landed at Hong Kong 15 strong, but of this number 4 have died and 4 have been invalided, leaving 7 men who appear to have suffered from the general effects of this climate as much as the 8 men previously detailed.

"The third detachment embarked for Hong Kong July, 1846, and arrived here 18 strong. Of these 5 have died, 2 been transported, leaving 11 now doing duty. These men have also suffered severely from the climate.

"All the men of these three detachments have served longer in Hong Kong than the other troops of the Garrison. Allow me to mention that after the arrival of the last detachment showing no immediate intention of relieving them, the good men's spirits seem broken and the drunkards get worse. The duties the Sappers have to perform here are more severe and trying than other troops', being constantly obliged to be out in a burning sun superintending contractors and other works, whereas the men of the regiments are not allowed to be out of their barracks between 8 a.m. and 5 p.m. It is supposed the period of service here for the Ceylon Rifles (Malay) and European Regiment to be three years, whereas the first detachment of Sappers have been upwards of seven years from England.

"Out of 67 men sent to Hong Kong up to October last the casualties amount to no less than 41. Under these circumstances I think it becomes my duty to represent the case of their speedy relief for serious consideration.

"It is with much satisfaction I have the pleasure to report the conduct of the last detachment arrived here in October last to be *most exemplary, no crime* having as yet been recorded against any *one man.*"

We now make a jump to 1862. This item consists of a copy of "The Field Journal of Operations undertaken against the (Tai-ping) rebels in the vicinity of Shanghai between the 4th April and 11th June, 1862, compiled by Lt.-Col. H. C. B. Moody, R.E., Captain C. G. Gordon, R.E. and Lieut. Sanford, R.E."

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The journal is divided into six expeditions, as follows :—

No. 1. Expedition to rebel entrenched camp at Wong-Ka-Dza—3rd and 4th April, 1862.

No. 2. Expedition to the rebel entrenched camp at Chaou-fou—17th and 18th April, 1862

No. 3. Expedition to the rebel fortified walled town and depôt Kuh-din, including the attack on the redoubts and stockade at Nesiang—26th April to 2nd May, 1862.

No. 4. Expedition to rebel fortified walled towns of Tsing-foo, strongly entrenched village of Nan-jow and fortified walled town of Tso-lin—7th May to 22nd May, 1862.

No. 5. Expedition to evacuate Kuh-din—(no dates given).

No. 6. Expedition to evacuate Tsing-foo—(no dates given).

The first three expeditions seem to have been of the military promenade type and present no particular features of interest.

The fourth expedition was a more ambitious affair. In this, as in the previous expeditions, it was carried out by a mixed force of British and French, both nationalities sending a naval brigade as part of their contribution. Lt.-Col. Moody estimates the total allied strength at 2,500 bayonets.

The R.E. were represented by Lt.-Col. Moody, Captain Gordon, Lieuts. Sanford and Maud and 26 O.R. of the 8th Company, R.E.

The journal of this expedition covers about twelve pages of foolscap, so I will not refer to it further, but pass on to No. 5, which possesses a special interest, due to the fact that Gordon was the C.R.E. owing to the sickness of Lt.-Col. Moody.

The R.E. detachment on this occasion consisted of Capt. Gordon, Lieut. Maud and 16 O.R. of the 8th Company, R.E.

The journal reads as follows :—

" On the 24th May, 1862, an expeditionary Force, consisting of the Wings of 31st Regt. and 33rd Punjab N. Infantry, French's and Wortham's demi-Batteries of Field Artillery and a detachment of Royal Engineers under Captain Gordon, R.E. The whole under Brig.-Gen. Staveley, C.B., started from the Stone bridge (Shanghai) at 5 a.m. and proceeded towards Kah-ding.

" The Force reached ' Nesiang ' about 11 a.m.

" The stockade outside the town (which was taken on the 29th April, 1862, was reoccupied by a detachment of 22nd Punjab N. Infantry. Here the troops halted until the arrival of the boats, which (being detained by the tide) did not arrive until between 4 and 5 p.m., when it was considered too late to advance upon Kah-ding, and as it was known the rebels were in the neighbourhood it was determined to halt for the night, and push on early the next morning.

" Some of the Commissariat boats only arrived *this morning* about 4 a.m., owing to their being too large and having thereby to wait for the flood tide.

" About 6 a.m. a body of rebels were observed advancing on the left

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of the town—about 300 of 22nd Punjab N. Infantry proceeded at once to drive them back (as also a party of rebels attacking the stockade) and after a sharp skirmish succeeded fully.

" During the course of the day the rebels attempted to drive in an out-lying picquet on our left flank, but without success.

" In these skirmishes about 100 rebels were killed and 2 of Punjab N.I. wounded.

" During the day every effort was used to push the boats through the creek which flows through the town.

" It was determined this day to push on to Kah-ding with a small portion of the Force and relieve the Garrison at that place.

" This expedition started about 5 p.m. and reached Kah-ding without meeting any serious opposition.

" In about two hours they spiked all the Chinese guns, destroyed all the rice captured at the taking of the place on 1st May, and then returned (preceded by the Imperial Chinese) to Nesiang, which place they reached about 4 p.m.

" During this day the rebels were observed hovering round Nesiang in large numbers. They made some desultory attacks on our outposts, but with no results, except a loss to themselves of some 20 men.

" It being determined, if possible, to recover a field-gun taken a few days previously from a small escort proceeding to Kah-ding and hearing that it was at the village of Wong-poo (?Wham-doo) (*vide* sketch), a distance of some five or six miles, a small party started about 6 a.m., but before proceeding any great distance, a report of firing was heard in the direction of Shanghai (*vide Note*).

NOTE :—The firing heard came from some Imperialist camp outside the city and was of no serious importance. The Chinese sometimes fire their guns like watchmen of old (and Chinese watchmen of the present day) spring their rattles to show they were awake and give notice to thieves, etc., *to get away in time.*

" From this it was thought possible that the rebels had made a dash at the settlement knowing that most of the troops were absent.

" Without loss of time, orders were given for all the troops to return to Shanghai and the greater part of the Force reached Shanghai at 3 p.m., *having seen no rebels.*

" The convoy of boats and their guard, etc., returned about 9 a.m. on the 28th May, 1862."

Lt.-Col. Moody's report on these operations addressed to the I.G.F. and dated 26th August, 1862, appears to be worth quoting in full. Gordon seems to have made an excellent impression.

" I have the honour to forward the accompanying reports, etc., o the late operations in the neighbourhood of Shanghai. I had hoped to have forwarded a copy of the General Order relative to the same before this, but, though the Brig.-Gen. informed me he would publish one as soon as the proceedings were over, as yet none have been published.

" Relative to the officers and men of the Corps under my command nothing gives me greater pleasure than bringing their constant zeal and gallant conduct to your notice and favourable consideration.

" With reference to Captain C. G. Gordon, R.E., the 2nd in com-

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mand in the field, I cannot speak in terms too high—always willing, zealous, active and, when work was to be done, in fact, indefatigable.

" In fact he fully bore out in all things the very high character I had previously heard of him.

" I am also able to enclose the accompanying letter from Captain Gordon, R.E. relative to Lieut. Sanford, R.E. I can fully corroborate his statements as far as the short period he was under my command permits me, and such a statement as Captain Gordon's in favour of Lieut. Sanford bears its own weight.

" The conduct of the men in the field was also highly satisfactory.

" I regret that it was not considered advisable to confirm the acting rank given (subject to your approval) by me to 2nd Corpl. Collins, 8th Company, R.E. At the commencement of the operations he was the only Sapper with me, he was also Acting Foreman of Works and indefatigable at Shanghai in superintending the erection of the defence at Stone bridge post near Shanghai, the work being performed by Chinese workmen (most difficult to deal with) and in unfavourable weather and under a general pressure of work. His conduct in the field I considered also highly satisfactory, and as such I wish especially to bring his name to your favourable notice for services performed.

" I regret to state that of late there has been much sickness among the men of the Corps, and the strength of the Company is very seriously reduced. To perform routine duties we are now very weak-handed—any extra ones are performed under serious pressure.

" I may also say the same of the Civil Branch of the Department, as I had to detach Mr. Medlin, C.W., to Shanghai where he is at present.

" Mr. Studd, C.W., at Hong Kong I expected to have to invalid shortly and have only Mr. Taffs, Hd. Qr. Clerk of Works, for duty here.

" Mr. Rawling, C.W., was lent to the Civil Government here, and it would seriously impede the progress of the public works to cause him to return to his duty, and from all I can learn he is doing his duty with great credit to the Department to which he belongs.

" Should there be any chance of further operations here (and events uncontrollable by us, may force them on us and at a short notice) we are so short-handed that we could not meet any serious demands; and the extra work on the few already available would soon exhaust even the present limited supply.

" The 10th Company, R.E., was sent from here previous to my arrival, and previous to any of the late signs of hostility—nominally indirect, but which sooner or later must have been directly developed."

It will be noticed that the troubles of a C.R.E. have not altered much in the last 60 years.

The next item is a copy of a memorandum addressed to the I.G.F., by Lt.-Col. Moody, dated 9th June, 1862, in which he complains that he, as C.R.E., was practically ignored during the preparations for these expeditions, was given no opportunity to furnish his views either as to engineer requirements or the scheme generally. He criticizes the commander of the force (Brig-Gen. C. Staveley, C.B.), with considerable freedom and mentions his opinion that the general field operations would have been as successful as the Engineer operations but for a certain order, against which he deemed it his duty to remonstrate and was told to mind his own business.

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He raises an important question of principle in the following words :—

"I have therefore to request information and guidance on the following subjects—am I as C.R.E. in China to witness what I considered a grave military error, and not give notice?—and would I not be held personally responsible by you and H.R. Highness if I did not jealously consider the honour of our arms, as well as the serious position we would be placed in by the loss of prestige in any manner?"

Moody seems rather to have thrown the fat into the fire by this communication, which "merited the extreme displeasure of H.R.H. The Commander-in-Chief." Several pages of the book are now taken up by explanations and apologies which are too long and hardly suitable for publication.

All the same, I think that a good many R.E. officers, especially those who were C.R.E.'s of Divisions in the Great War, will feel a good deal of sympathy with poor Moody.

The next is an interesting item, being a copy of Gordon's official application for permission to accept service under the Chinese Government. It is short and to the point.

Shanghai, 25th December, 1862.

Sir,

I have the honour to request that you will move the Brig.-General Commanding the Forces in China to forward this my application for the permission of Her Majesty to accept service under the Chinese Government.

I have, etc.,
(Signed) C. G. GORDON,
Captain, R.E.

D.A.A.G.
SHANGHAI.

This led to Gordon's connection with the "Ever Victorious Army," and laid the foundation of his future greatness.

The last item is a memorandum to the I.G.R.E., dated 29th June, 1863, by Lt.-Col. Moody, who appears to have survived the little trouble of the previous year.

It furnishes an interesting echo of the recurrent squabbles which on more than one occasion nearly led to war between England and the Union Government during the War of Succession in America.

"In consequence of an alarm of an immediate prospect of war with America, and the fact of a heavily-armed American Frigate, and two gun-boats being reported at Macao—and in the absence of a naval force in our own waters and the very insufficient existing land defences, His Excellency the Acting Governor ordered a Council to assemble and requested my attendance to give any assistance as C.R.E.

"On a previous occasion of a similar alarm, I, in conjunction with the Offr. C.R. Arty., selected certain sites for defensive batteries, but they were for Armstrong guns (110-pr.). That alarm was soon over,

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and as it would have entailed extra detachments and duties on an already hard-pressed garrison if these batteries were erected without urgent cause, the service was postponed—and none of the £500 authorized has been expended. (*Vide* joint report, dated Hong Kong, 7th October, 1862.)

" There would have been no difficulty in occupying these sites already selected *had the Armstrong guns arrived*—but they have not; only the Ammunition has come as yet.

" These sites were not available (owing to the ranges) for any shorter-ranged guns, so fresh sites had to be selected to meet the limits of the defensive weapons available.

" The batteries are revetted on the Kowloon side with Commissariat Casks—Embrasures with Jones patent Gabions—on the Hong Kong side; the Commissariat had broken up their casks so we used the patent Gabions throughout.

" Detailed plans and estimate will be furnished by the earliest opportunity. I merely send this preliminary report for your information.

" The expense will be comparatively trifling—but I feel the want of Sapper superintendence very seriously—our detachment here is so very weak for the duties they have to perform and the men are constantly breaking down, as shown by the number of invalids sent home from time to time and also by the present weak state of the 8th Company, R.E.

" I am led to expect that I will be able to remove the Head Quarters of the 8th Company, R.E., from Shanghai to Hong Kong before long.

" This will give me a great assistance."

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THE LIGHTER SIDE OF "I."

By LT.-COL. E. P. LE BRETON, R.E.

INTELLIGENCE and Spy are terms of high romance only second to those glowing words "Pirate" and "Buried Treasure." Innumerable spy novels, many spy plays and a respectable number of Intelligence officers' memoirs have been given to the public in the last six or seven years. They vary, of course, in merit from the *Thirty-nine Steps* and its sequels: Books that will rank with *Treasure Island* itself to the Penny Dreadful of commerce. They have, however, one common quality,—they none of them remotely resemble the truth. The writer of this article was for the greater part of '18 an insignificant cog in the machinery of the Intelligence of one of our Eastern Armies.

The incidents he here sets down, though less exciting than is common in spy stories, have the rare, the all but unique, distinction of being true. Names, places and regiments have, of course, been suppressed or altered.

* * * *

All women and six men out of ten envisage the head of the Intelligence of an army as a cosmopolitan individual who periodically envelops himself in a false beard and fades away. He then proceeds direct to the dwelling of the enemy commander-in-chief. Having entered the palace, the camp or the bivouac of the Hindenburg of the moment, our Intelligence officer either :—

(*a*) kills one of Hindenburg's staff, steals his uniform and passes himself off as the victim, or

(*b*) conceals himself in a cupboard in Hindenburg's office, or

(*c*) hangs by his finger-nails to the window-sill some eighty feet above the ground.

No sooner is the scene laid than Hindenburg and his Chief-of-Staff enter. Are they overheard complaining about the quality of war bread, the disgraceful way their new orderlies clean their buttons or the absurd nonsense written by War Office clerks? Not a bit of it.

They begin at once something like this :—

Hindenburg: Ah, good morning, Count.

Enemy Chief-of-Staff (saluting, bowing and clicking his heels): Your Excellency.

Hindenburg: At last we have them (hits table with closed fist).

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As you know, I have prepared a trap for them, and the fools have fallen into it. They think I am about to attack their centre—Not so! At dawn on Tuesday 200 Army Corps advance to crush their left flank and sweep them to perdition.

Enemy Chief-of-Staff (saluting, bowing and clicking as before) :—Your Excellency is irresistible.

This is enough for our hero; he fades again, and reappears on the nearest beach or open field. Thence he is retrieved by a friendly submarine or aeroplane and taken back to the British lines. Still enveloped in his false beard, he walks up to the British commander and asks for a private interview. The Staff are horrified, but Field-Marshal Lord Jones, with his shrewd and kindly smile, dismisses the crowd of scarlet-throated popinjays who surround him and beckons the unkempt stranger into his sanctum. Some twenty minutes later the Marshal emerges. In a few well-chosen words he shifts 250 Army Corps from his centre to his left and the situation is saved. The work of the Intelligence is done.

* * * *

As a matter of unromantic fact the Intelligence Staff at a General Headquarters are a set of tired overworked men, constantly exploring false trails, for no chance can be lost, gradually building up, from an indication here, and a report there, statistics of the enemy's forces, records of their movements and plans and sketches of the characters and dispositions of their leaders.

With every confidence (and in the certainty of being contradicted by "Operations," "A," "Q," and the other branches of the Staff), I state that the work of the Headquarters Intelligence Staff is the hardest, the most exacting and the most exhausting in the army. At Baghdad the "I" branch assembled daily shortly after 8 a.m., and, with brief intervals for lunch and dinner, worked at high pressure till 11.30 p.m. seven days a week, for Sundays do not occur in war. Month after month, and year after year, there were no intervals for rest It was safe, but it was not an easy life. And Intelligence work is all original brain work. There are no comfortable matters regulated by routine, drawn out by a well-trained clerk and signed after a casual glance.

Moreover, it is impossible to file precedents and records so that all one's knowledge can be handed over with the key of the safe to a successor. No Intelligence officer is worth much till he has stored six months of memories in his brain, and the longer he stays the more valuable he is. Consequently, though the General officers at the head of the various G.H.Q. Intelligence Staffs were among the best soldiers the Empire has produced, their very value sometimes prevented their promotion to the high commands which they would otherwise have attained. The Chief of the Intelligence of an army

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in the field may be said to be the only exception to the maxim that no man is indispensable.

For those who don't like that sort of thing, it is the sort of thing they will most heartily dislike. For those who do like it, Intelligence work has an overpowering fascination.

* * * *

The work is very varied. All foreigners are dealt with by the "I" branch. In Baghdad this was a formidable part of the functions of the Intelligence. Masses of Russian refugees from the broken fragments of the Imperial army, prisoners of war of every nationality who had escaped from the Bolsheviks and made their way to Mesopotamia, enemy officials and free-lances who had been apprehended in Persia, friendly free-lances who were almost more trouble (all through the war swashbucklers of every nation pervaded that ancient but unhappy land), and lastly organized missions sent out by one or other of the amazing Governments from which most of the Allies suffered.

A certain Russian Colonel, whom I still remember with vivid dislike, would send for me day after day at my busiest time. "You spik ze French—Yes? No?—I can my complaint make much more couramment in ze French" and then followed the day's complaint—half an hour at least. We still hoped for help from the Russians. They could not be spoken to as they deserved. One of the lesser gems of official correspondence was sent me by a young officer I had deputed to meet a party of Russian refugee nurses arriving by train from Persia.

It ran :—

Sir,—In compliance with your instructions I met the Russian nurses arriving at Hinaidi railway station at 21 hours last night. On alighting from the train one of the ladies was safely delivered of a female child. Your further instructions are requested as to its disposal. Both mother and child are doing well.

(Signed) J. BROWN,
Captain Gen. List.

Poor little lass! —it was a dismal place to start from.

Then there was a Balkan nobleman who had escaped from Odessa, and married a wife on the way down. We thought rather well of him at first and we lodged them in an official guest house we kept in the city. Unfortunately he had a weakness for arrack, and that night he was seized with the conviction that our harmless and aged Moslem doorkeeper was Sultan Abdul Hamid in person. With a drawn sword in one hand and a loaded revolver in the other he chased that dignified official half over Baghdad before the police intervened and brought him to the "I" Branch in handcuffs.

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He started on his long trail back to Eastern Europe the next day minus the revolver and its ammunition.

Propaganda formed another of our many sub-branches. Propaganda at home is a comparatively straightforward matter. Having decided on some simple fact that the nation is to believe, you repeat it *ad nauseum* until some wit forms it into a popular catchword and the trick is done.

In Mesopotamia it was a more subtle affair. We had propaganda for the Turk and for the Kurd, for the nearer Persian and for the Azerbaijan Tartar, for the Shirazi, the Armenian, the Yezidi and the Baghdadi, for the Bedouin Sheikh, the Chaldean Christian, the Moslem Ulema, the Jew and the Yankee. In each case the facts had to be—presented somewhat differently—shall I say.

This complicated business was concentrated in the hands of a witty and able sportsman from Wales. He is nearly seven feet high and his desk looked like a torpedoed haystack. Yet he could always plunge an unerring hand into the tangled mass and produce appropriate literature for any of the nations, peoples and languages with whom we had to do.

I only remember one disastrous mistake, and the responsibility for that lay with the Air Force. We had on hand two lots of propaganda. No. 1 was for the Tartars of the north, who were showing signs of throwing in their lot with the Turk. No. 2 was for the Shirazis of the south. No. 1 reminded the Tartars that they were Persians before all and besought them to hold fast to their old allegiance, not to lose their freedom to the Turk, their ancient enemy. No. 2 reminded the Shirazi that the Tartar was not a true Persian; that, in fact, he was little better than an accursed Turk. It exhorted the men of the south to hold together and prepare to resist the union of Turk and Tartar. No. 1 showed that if the Tartars went over to the Turk all Persia would be left in the hands of the Shia sect. No. 2 emphasized the disappearance of the Shia faith which would follow a Turk-Tartar coalition (where have I heard that word before?) sweeping into Persia from the north.

All Persian writing looked alike to our Airmen.

You see what happened?

We managed to stop the Shirazi getting the Tartar propaganda, but Azerbaijan was white with the propaganda meant for Shiraz. It didn't really matter much, as the Tartar had already committed himself to the Turk and the Bolshevik, but it caused some consternation at the moment.

Our Propagandist, once widely known in Baghdad as "Pongo of the 'I' Branch" now serves in one of the few really human ministries in Whitehall, while his leisure hours are given to a fortunate and very individual troop of boy scouts in a crowded part of London. Deserters, prisoners of war, captured documents, the censorship, the

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Desert Blockade that starved the Turkish Forces, the records of the innumerable Arab chiefs and Persian notables and of their shifting sympathies, the making and distribution of maps of the all but unexplored lands behind the Turkish lines, all fell within the province of "I."

Spies, or rather "agents,"—it was considered very impolite to refer to the knaves who did our dirty work as "spies." The enemy used spies, we employed "agents." Agents, then, were dealt with by a separate branch of "I" which lurked in a house in the city, with a bolt-hole on to the Tigris. The information gained by spies is of trivial importance compared to that obtained from deserters, prisoners, aeroplanes, etc. The Eastern spy is always a liar. They were, however, to a certain extent useful for keeping in touch with affairs at the enemy H.Q. in Mosul, and we had a well-organized department which procured them and sent them out. It is obvious that an agent is greatly tempted to work for both sides—he doubles his profits and halves his risks.

In the Aden Hinterland (that murkiest of side-shows) our agents hardly troubled to pretend that they were not working for the Turk as well as for us, and I always suspected that most of our Mesopotamian ruffians drew pay simultaneously from the rival G.H.Q.'s at Mosul and Baghdad.

The obvious corollary of an organization of agents is a counter-organization to prevent the enemy spies getting any useful information.

Counter-espionage is a very difficult affair at the best of times. In an Eastern country it is a heart-breaking business. Every native servant to an officer, every employee at a Church Army or Y.M.C.A. hut, at a club or an hotel, and all the gay ladies of Baghdad had opportunities of acquiring information worth much money if brought to the right market.

Amateur spy-hunters abounded. They always do. I believe even in England spy-hunting was a not unpopular sport. They were generally wrong, but we always carefully investigated their stories. The clearest case on record of signalling to the enemy was discovered by one of my subalterns while we were assisting to hold an infernal place called Sheikh Othman.

We went swiftly to Brigade H.Q. and from the roof of their billet were able to point out the flag-wagger, still at it, to the G.O.C. A guard was produced and the hunt started.

Sweating like bulls (the climate of Sheikh Othman is warm even for Arabia), they surrounded the offending house and found on the roof the C.R.A.'s red blanket airing itself between two poles.

One hot-weather morning at Baghdad, as we sat and dripped slowly each on his own pile of files, we became aware of a loud and confused noise without. I went out and found the Abbot of the

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French Monastery in the city. His hands waved wildly up and down till they all but vanished into a haze. His beard and cassock flapped as if in a hurricane while he poured a torrent of agitated French on to two wooden-faced Intelligence police. I drew him into an empty room and soothed him. The English and the Scotch are the only nations who come to the point at once. My Prelate was no exception to the general rule, and I sat down sadly to an eloquent and patriotic disquisition on the aims and feelings of France, her passionate affection for the English and the fervour with which the Abbot himself shared the attitude of his countrymen. It wasted nearly half an hour, and half-hours were very precious, but I knew from sad experience that any attempt to stop this preliminary spate of eloquence would merely aggravate the offence.

When we "got to the 'osses" the story was interesting. The Monastery has been for many years a power in Baghdad. The monks have for generations educated the children of the notables, whether Moslem, Christian or Jew. So established were they as an institution that even the Boche did not dare to interfere with them, and under Turk and German, as later under the Union Jack and now under Faizul the First, the great Monastery goes quietly on in its accustomed path. The buildings are large and solid enough to stand a siege. They are situated in the heart of the city, surrounded by a network of native bazaars. To them, the Abbot said, had come two British officers who held the Catholic faith. They had asked for a private room in which they might sit and talk by themselves. They had further indicated that if they were pressed to partake of Irish whisky it would not be unacceptable. The monks (I have omitted another small pæan of eloquence on the Entente which, to my horror, burst out at this point) were delighted to entertain any soldier of England and glad to find Catholics amidst the waste of heretics. But the next week the incident had repeated itself and now on each successive Friday at 11 a.m. the two officers appeared, took their room and their whisky, conferred for an hour and departed. A horrid doubt assailed the men of God; could they be harbouring spies, enemies of France? And whisky so expensive withal! Well, it sounded promising. We arranged that next time it happened, news should be brought us at once. Next Friday the Abbot appeared again, if possible more agitated than before—the birds were in the covert. Two A.P.M.'s were procured. A life preserver was pressed into my hand. We shovelled the monk into a car and hurried to the Monastery. The Monastery is two stories high and built round a hollow square. All round the first floor runs a projecting balcony reached by wooden staircases from the cobbled square. The Abbot led us into the courtyard, pointed out a door on the first floor, murmured that he was a man of peace, picked up his skirts and fled down a passage.

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Pointing out to the A.P.M.'s that the apprehension of criminals was a police business, I suggested that they should lead the rush. The A.P.M.'s, however, held that they were merely present to support the General Staff. Finding myself in a minority I led the way quietly upstairs.

We gathered for a moment outside the door and then, throwing it open, burst into the room. There we found two gentle and much-surprised soldiers, a subaltern of Commissariat and a corporal from a Heavy Battery. Feeling a number-one-sized ass, I demanded and obtained particulars. (Particulars which I afterwards checked and found correct.) The Abbot's "spies" were old school friends, one commissioned, one a non-commissioned officer. Owing to the etiquette of the Service they could not meet freely in public. As they were both Roman Catholics they had devised this harmless and inexpensive method of entertaining each other at the expense of their Church. Unfortunately, Lieut. Jones had a sense of humour.

Thenceforward, whatever function I attended at Baghdad I became aware of Lieutenant Jones eyeing me with a slow quiet smile. He became an obsession. A real ghost would have been less objectionable. I consulted the A.P.M.'s—they suffered from it, too.

* * * *

A minor difficulty which beset the higher command in the last phases of the war was the reluctance of post-war officers to sanction or inflict severe punishment for an offence of a strictly military nature. But the safety of the army does require this duty from those officers to whom it falls to try such offences.

Similarly, it is essential that a convicted spy should suffer the extreme penalty. The rewards of the successful spy are large. Many men will risk imprisonment to gain them, far fewer men will risk death. Consequently, if, in the rare cases where spying can be proved, the criminal is shot, spying as a trade goes out of favour and casualties to our own men are saved. For in the end the aim of the spy and the result of his work are to increase the casualties of the army spied on.

I have in mind two glaring cases of this sort. A native of Persia was found attempting to pass through our lines with a code message to the enemy concealed in his hookah stem. The evidence was clear; it was assumed that, if convicted, no court of officers could do other than sentence him to be shot. In order to convict him it was necessary to prove that the letter was one to the enemy and consequently to disclose the fact that we could read this particular code. The prisoner was convicted, but was only sentenced to a comparatively short term of imprisonment. There can be little doubt that this leniency encouraged spying, and that he managed

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to convey to his employers the fact that the code used was a "compromised" one.

In the second case one of our "superior agents" was convicted of sending information to the enemy. These men did not work as agents themselves; they were used to procure men willing to act as spies as and when we required them.

The man in question let us call him by the fictitious name of Sheikh Kabir, was trusted by the "I" branch and was much employed in this work. In the spring of '18, Sheikh Kabir's father arrived in Baghdad from Mosul. He said that the Turks suspected his son's activities on our behalf, that they had brutally ill-used him in consequence and that he had barely escaped to us with his life. We were taken in and he was given a grant of money for subsistence. He then, unknown to us, returned to Mosul where he was a Turkish agent. Two or three months later Sheikh Kabir called up a spy, whom he had used on our behalf before, and sent him, with a letter for the enemy, to his (Sheikh Kabir's) father in Mosul. The spy, an honest man, as spies go, thought he was still acting for us and on his way back gave the answer and the payment for Sheikh Kabir's treachery to a British Intelligence officer whom he met en route. The fat was in the fire, and on enquiry Sheikh Kabir's dealings with the enemy were proved without doubt, but to the encouragement of all traitors he escaped the fate he so richly deserved. No nation has ever produced finer soldiers than our "New Army officers" but their clemency in these matters showed a curious and isolated flaw in their sense of duty.

The incidents described above deal mainly with failures, but I do not think the Intelligence of our armies in the field requires defence. I have on one occasion sat in a room while our interpreter read off the telephonic communications of the G.O.C. of the Turkish Corps on our front. They had left a wire behind which was discovered to be still in connection with their telephone system; an instrument was hitched on and for the better part of three eventful days we wrote down, as issued, a large part of Ali Akbar Bey's operation orders.

The last message we got gave us some amusement. The Bey sent for his signal officer. "Did you" he asked "cut all the telephone wires behind you as we retired?" "I cut them, sir," he said, "with my own hands." He was only anticipating the truth; half an hour afterwards there was a slight click and that source of Intelligence ceased to function. I hope the signal officer escaped detection, we were very grateful to him. And now I am faced with the task of finding a suitable peroration wherewith to end these discursive notes. Perhaps, it would be better simply to stop.

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MAP-MAKING FROM AEROPLANE PHOTOGRAPHS

A Lecture delivered at the S.M.E., Chatham, on 8th March, 1923, by MAJOR M. N. MACLEOD, D.S.O., M.C., R.E., *Chief Instructor, Artillery School, Larkhill.*

THE idea of using photographs taken from the air for making maps is no new one. Long before the war continental investigators had devoted a good deal of study and experiment to the question and had elaborated apparatus and procedure for this purpose.

These experiments do not seem to have attracted much attention in England, and though I have been told that we did get as far as purchasing an aerial camera, designed by an Austrian named Scheimpflug* and intended for use in a balloon, this camera does not appear to have been used and cannot now be found.

During the war, however, the question of mapping from air photos received a fresh and powerful impetus, and the lessons and experiences derived from it are summed up in the Introduction to the Report on Surveys on the Western Front, which states that "Air photography is of fundamental importance to survey in war," and goes on to add: "A clear policy should be laid down for co-operation between airmen and surveyors, and research should be carried on in the development of methods and apparatus, for use both in the air and on the ground."

The particular attribute of aerial photography, which is of "fundamental importance in war," is that it is the only method of survey which can be applied to regions inaccessible and invisible to the surveyor on the ground.

At present, as will be seen, we cannot apply it to regions which are completely inaccessible, but it is to be hoped that further research and development will enable us to do so.

Such a development will have an important bearing on tactics, because the tactics and training of troops depend in great measure on the nature of the maps in their possession, and it will entail a complete revision of our ideas on the subject of tactical maps.

Hitherto the nature of the map issued to troops has depended, not on what sort of map would be of greatest value, but upon what sort of map happened to exist at the outbreak of war.

If we can devise a satisfactory method of mapping inaccessible areas we will be in a position to give to the troops the type of map which will really be of most use to them.

* Described in *R.E. Journal*, September, 1910, page 219.

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Before the war our tactical maps were small-scale maps because, in most probable theatres of war, nothing but small-scale maps were to be expected; during the war it was soon found that the small-scale maps first issued were inadequate; and at the end of it, we had not only produced accurate large-scale maps for general use, but had elaborated methods of fighting which depended absolutely upon them.

We have now to forecast the conditions under which future wars will be fought and to come to a decision as to whether we shall be able to use these methods, counting on the possession of a suitable map, or whether we must go back to our pre-war ideas.

I think that most officers who have used a large-scale map can think of reasons which make the provision of large-scale maps desirable, but there are one or two reasons which, in my opinion, make the provision of such maps, not only desirable, but almost essential, at any rate in large wars.

Of these reasons I will give only one. It is this :—

When great masses of artillery are deployed on the battlefield, the old method of fire direction by ranging and registration breaks down. A large number of batteries cannot range on a limited area at the same time because of the impossibility of distinguishing the shells of one battery from those of its neighbours. Ranging, if done at all, must be done by batteries in succession, causing great delay, and, as we found by bitter experience, generally resulting in premature disclosure of the tactical plan.

Ranging, however, can only be dispensed with when it is possible to locate the target as well as the gun with an accuracy commensurate with the performance of the gun, that is to say, within somewhere about 20 yds. of the truth.

The gun can be visited by a surveyor and can be fixed by other methods, but the target is often invisible from our own lines and can then only be fixed from the air with the aid of a map, sufficiently accurate, and of sufficiently large scale. The smallest scale which will give the accuracy really necessary is about three inches to a mile. It is important also to remember that, in hilly country, accuracy of heights and contours is almost as important as accuracy of position.

The artillery are naturally anxious to know if they can count on having such a map. In almost all tactical schemes they are called upon to arrange for barrages and counter-battery action, which can often only be done if they are given a suitable map; in their own training, also, it is essential that they should know if they will be able to use the procedure and methods evolved during the war.

It is the duty of the Corps to produce and supply maps, and it is to us that they look for an answer to this question. Unfortunately, we must admit that we are not yet in a position to give it.

The fact that we were able to produce large-scale maps in France

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with the aid of aerial photographs does not imply that we can do so elsewhere by using the same methods.

In France there was available, in the *Cadastre*, and in the French systems of triangulation and levelling, a wealth of topographical data which we could and did make use of.

Without any help from aerial photography we should have been able to produce an accurate though not very detailed map.

The aerial photograph in France was used mainly for putting in trench systems and filling in detail on a framework already complete as regards the main features.

The survey of a complicated trench system would be a slow job for a ground surveyor under any circumstances. A vertical air photo which shows it in full detail in plan is obviously an excellent way of mapping it, provided the framework is there first and enough of it appears on the photo.

When there is no such framework it is a very different and much more difficult proposition, as was found in Palestine, Salonika and Mesopotamia. Even in France the air-photo had more limitations than most people realized and some of our first attempts at mapping from them were sad failures !

To understand the problem of mapping inaccessible regions we must consider these limitations.

A photo taken from the air in such a manner that the plate is parallel to the ground at the moment of exposure will give a print analogous to a map whose scale is the focal length of the camera, divided by its height above ground. We must obviously know what this scale is before we can make use of the photo. If, as in France, we have the main outlines of the map complete and only require the photo for filling in such things as trench systems, some of the map features are sure to be visible on the photograph and we can deduce its scale from them. When we have not got such a framework to start from, it is not so easy, because our instruments for measuring height in an aeroplane are not accurate enough for the standard we require in the map, and measure, not the height above the ground below the aeroplane, but the height above the starting-point of the flight.

However, when the ground is hilly, a flat plate cannot be placed parallel to the ground. It may, perhaps, be placed horizontal but most of the ground will not be horizontal ; it may slope at all sorts of angles, all of which are unknown.

Consequently the image of the ground on the photograph will be distorted in all sorts of ways. The " detail " will all appear on the photograph, but it will not be in its correct place, and we cannot make a map by simply enlarging and copying it.

Now it may be thought that, except in mountainous country, the distortion should not be very great and that in ordinary country

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it might be neglected. This depends on the standard of accuracy required in the map. In France the generally-accepted standard was that the absolute position of a point shown on the 1/20,000 map should be within 20 yds. of the truth. When we remember that the artillery want to use the map for fixing the positions of their targets, and that the " 100 per cent. breadth zone " of most guns is less than 20 yds., it is evident that this standard is not too high. Yet a point only 300 ft. above the general level may be easily displaced by the equivalent of 20 yds. on an aerial photo. If we work to this standard it means that in country where differences of height exceed 300 ft. we must take this distortion into consideration.

Again, we must also remember that in hilly country an essential, and often the most important point of the map, is the contouring, and the aerial photograph does not show contours at all. As we have to show ground forms we must find some way of deducing the heights of points from their " displacements " (*i.e.*, the distortion) on the photograph.

In practice, when the camera is carried in an aeroplane, it is not even possible to ensure that the plate is always horizontal. An aeroplane vibrates, rolls and pitches. If the camera is rigidly attached to the machine it will partake of these movements ; if, on the other hand, it is suspended in gimbals, or attached by any sort of pendular suspension, acceleration or deceleration, banking, etc., will give rise to centrifugal forces which are unnoticed by the pilot, but which are quite sufficient to tilt the camera out of the vertical to quite appreciable amounts. Superimposed on the distortion due to irregularities of the ground there may be, therefore, a distortion due to the fact that each plate exposed is inclined at a different and unknown angle to the horizontal.

These distortions will naturally affect the size of the various parts of the image and will, unless we can allow for them, prevent us making a really accurate determination of its scale.

Nor do the difficulties end here, because the aeroplane cannot yet hover in the air ; on the contrary, it must keep moving very fast. Unless the exposure is very short indeed, the camera will move appreciably while the plate is being exposed, and a point on the ground will record itself, not as a point, but as a line.

At present our only way of giving very short exposures is by means of a focal plane shutter. A blind in which there is a narrow slit is drawn across the face of the plate. Usually the slit takes 1/50th second to travel across the plate. If it is 1/10th the width of the plate, each part of the plate will be exposed for 1/500th second. A point can thus be induced to record itself virtually as a point, but this does not get over the difficulty, because points on the first part exposed, are photographed from a slightly different view-point to those on the last part.

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Distortion due to this cause is small and for certain purposes can be neglected, but if, as is probable, we have to use aerial photographs for really precise work, we may have to take it into consideration.

Many attempts have been made to devise a satisfactory " between lens " shutter which will give very short exposures, but so far without success.

Lastly, there remains a possible source of distortion in the optical properties of the lens itself. It is not difficult to make a lens in which, when a wide aperture is necessary, there is no distortion in the *centre* of the field, but, as will be seen, in photographs required for mapping, the ability to photograph a large area at a single exposure is an important advantage. This factor limits the size of the field which can be included on a single plate.

Distortion of the image due to the shutter or lens will probably be eliminated by improvements in the construction and design of the camera. Distortion due to tilt and to irregularities of the ground must, however, always be reckoned with and allowed for by the way in which the photo is used after it is taken.

The distortion due to tilt may be dealt with in two ways. If the amount and direction of the tilt can be determined, the negative can be printed in a suitable enlarging lantern in such a manner that the resulting print is, so to speak, redistorted to what it would have been, had the camera been held vertical when the original negative was taken. This process is termed " rectification."

This would seem to be the simplest and most direct way of dealing with tilt, but, of course, it depends on the ability to discover beforehand what the tilt is. Were we able to devise apparatus for measuring and recording in the aeroplane the height at which each photo was taken, and the amount and direction of any deviation of the optical axis from the vertical, there would be no difficulty in obtaining from the aerial negative prints of any desired scale from which tilt distortion had been eliminated.

Unfortunately, we have not yet succeeded in doing this, and it is doubtful if we shall ever do so. Experiments are at present being carried out with gyroscopic devices for recording the direction of the vertical. If these prove successful we shall get over the tilt difficulty, but this will not touch the question of scale determination, which is, as explained, a function of the height above ground.

Up to the present we have been unable to measure accurately either tilt or height in the aeroplane, and have only been able to eliminate tilt distortion and determine scale when there appear on the photograph at least three, and in certain cases, four points, whose map positions have been fixed by some preliminary independent survey process.

The advantages of a wide field of view in a mapping camera are here apparent. The greater the field covered by each plate, the

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smaller will be the number of independently fixed points required in any given area.

It is here worth noting that the points normally fixed as " control points " for survey on the ground are not necessarily suitable for aerial photography. A mountain peak, for example, or a factory chimney, though an excellent point for a ground surveyor, may be quite impossible to identify correctly, and therefore quite useless for an aerial photograph. The points of an ordinary topographical triangulation, such as may be available when small-scale maps exist, will probably be altogether inadequate as " control " points for an aerial survey.

The mapping of inaccessible country by aerial photography therefore resolves itself into two problems :—

(*a*) The use of the aerial photograph to fix positions and heights of sufficient control points.

(*b*) The use of these control points to eliminate tilt and other distortion from subsequent photographs.

For neither of these problems can we yet claim to have found completely satisfactory solutions.

It is hoped to deal with the first by methods analogous to those used for photographic survey from the ground.

In survey by photography from the ground the photograph is not used to determine the position of a point directly, but only in its direction. If the direction of the optical axis of the camera is known, the horizontal and vertical angles to all other points on the plate can be deduced from linear measurements made on it. A point can then be fixed both as to position and height by photographs from two view-points whose positions have been surveyed. Photographs for such surveys are usually taken from tops of mountains with the optical axis horizontal.

In using this method for aerial work it is necessary to provide some means of fixing the position in space of the aeroplane, and of determining the direction of the optical axis of the camera. It is hoped to do this by constructing a " multiple " camera, which is, in principle, five cameras rigidly fixed together so that the plates form five contiguous sides of a cube, one plate being horizontal and the others vertical.

The intention is to expose these plates simultaneously, so that one vertical plate takes a photograph of the inaccessible area and at least one of the other plates a previously surveyed area.

From the horizontal plate, which may be expected to show " control " points, it is hoped to determine the position and height of the camera, the amount and direction of tilt, and the orientation of the whole apparatus. This orientation can then be checked from one or more vertical plates, and from the data thus obtained the

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horizontal and vertical angles to points in the "forward" area shown on the other vertical plates can be deduced.

Such a camera has just been completed by the R.A.F. and is undergoing trials. Its successful use evidently depends on our ability to deduce the amount and direction of tilt from the horizontal plate on which the control points appear.

Now the elimination of tilt distortion from a photo does not necessarily involve an actual determination of the tilt.

If four control points appear on the photograph, any other point on it can be plotted in its correct map position by a fairly simple construction, and the detail might be transferred from photo to map point by point in this way.

This method, which is described in the *Manual of Map Reading and Field Sketching*, 1921, is all that is required when it is only necessary to use the photo for locating a few new features on an otherwise complete map, *e.g.*, for getting the position of a hostile battery.

When much detail has to be thus transferred, it is possible, by means of a graphic construction, to draw on the photo a grid which would be the distorted image of some particular grid on the ground or map, and to draw in the detail from its relation to the corresponding lines, in the same way that a map is often enlarged or reduced.

Again, the photo may be projected optically on to an adjustable screen or copying board on which the control points have been plotted and the board moved about until the control points on the photo project into their correct positions.

These optical methods are, to some extent, still in the experimental stage, but it seems probable that they will eventually prove to be the best way of dealing with tilt distortion, when a complete map has to be made.

Only two methods of thus projecting the image need be described, the *camera lucida* and the projecting lantern.

Before describing them, however, it is advisable to consider the theory of rectification in order to understand the geometrical principles on which it must be based.

In the theory it is supposed that the photograph is a true perspective of the ground, that is to say, that straight lines joining points on the ground to their images on the photo all pass through a single point at the centre of the lens. If lens and shutter distortion are small, this is sufficiently near the truth.

Fig. 1 shows the geometry of the conception.

In this, P represents the plate and L the centre of lens. LC, the optical axis of the lens, is assumed to be perpendicular to the plate and to meet it at its centre C.

The distance LC is the focal length of the lens and can be determined before the camera is taken into the air.

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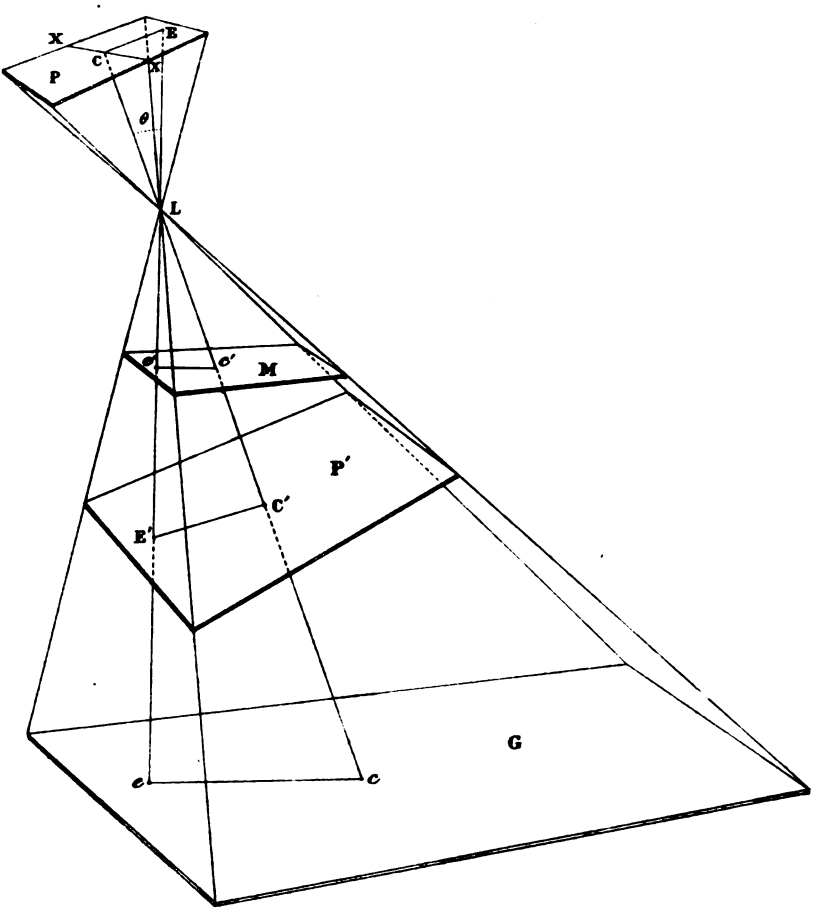
*e*LE is a vertical line, G the ground, and M a horizontal plane, such that L*e*′/L*e* is the scale, or R.F., of the map.

The map is regarded as a perspective from L on the plane M. It can be seen from the figure that the tilt of the photo, which is the deviation of the optical axis from the vertical, is determined by the line CE. CE is called the " principal line " and gives the direction

Fig 1.



of the tilt, while CE/LC is the tangent of the angle of tilt, lettered θ, whence its magnitude can be found.

The principal line represents the intersection of a vertical plane containing the optical axis with the plane of the photograph. A line perpendicular to it in the plane of the plate will therefore be horizontal. Such a line, lettered XCX, through the centre of the plate is called the " axis of tilt," and is, of course, not necessarily parallel to any of the sides of it.

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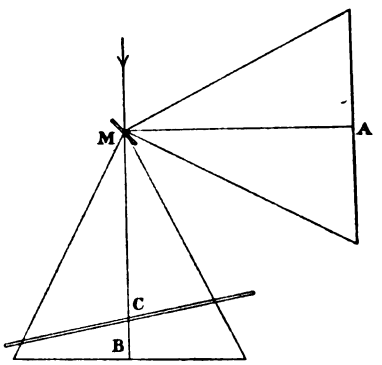
Optical methods of projecting an image of the photo on to a screen aim at reproducing the geometry of this figure. In the *camera lucida* the projection is done by means of a small sloping mirror, in which is sometimes drilled a small hole

If the photo is pinned up at A (*Fig.* 2) the mirror placed at M, and the operator looks into the mirror along the arrow, a virtual image of A is seen in the direction of B.

This image can be, as it were, intercepted by a copying board placed at C. The copying board can be seen through the hole at the same time as the image, which can be drawn in by running over the lines with a pencil.

To obtain an image of the photo from which tilt distortion is eliminated it is necessary to plot the control points on the board and then adjust the board so that these points coincide with the corresponding points, suitably marked, on the image of the photo.

Fig. 2.



If the mirror M is placed in the same relation to A as the lens of the aerial camera was to the plate, the geometry of the figure is clearly analogous to that of *Fig.* 1.

When the coincidence of points has been obtained, the copying board C in *Fig.* 2 will be in the same relative position to M as the plane M in *Fig.* 1 is to L.

This would enable the tilt to be determined, or conversely, if the tilt were known, the copying board could be set in the correct position.

The *camera lucida* was used a good deal during the war, particularly by the French. Though cheap, and simple in principle, it suffers from some important practical defects, rendering it troublesome and tiring to use.

In the enlarging or projecting lantern the image is thrown on to the screen by means of a lens and a beam of light. The control points may be plotted on the screen and both camera and screen adjusted until the points of the photographic image coincide with

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the plotted points. The process is generally similar to the adjustment of the *camera lucida*, but an additional complication is introduced by the necessity of getting a real image in sharp focus on the screen.

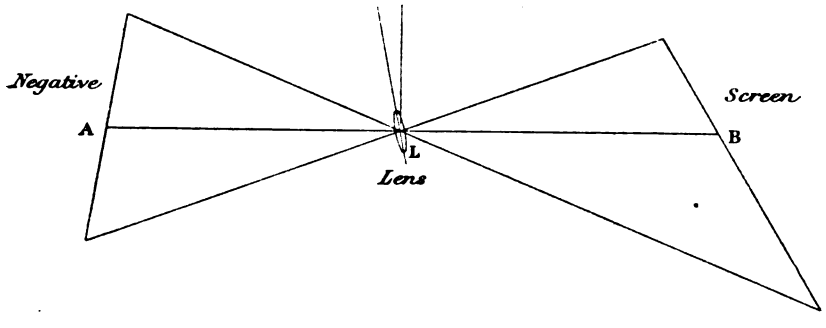
To do this it is not generally possible to place the lens in the same position relative to the plate, as in the aerial camera.

The geometrical conditions of *Fig.* 1 cannot, therefore, be reproduced exactly, and unless this is done the plane on which a rectified image is obtained will not be in the same position relative to the lens as the plane M in *Fig.* 1. It is not, therefore, a very simple matter to deduce the tilt of the aerial camera from the setting of a projecting lantern.

Fig. 3 shows diagrammatically the adjustments usually necessary to obtain a rectified image.

Practically the adjustment of either the *camera lucida*, or the enlarging lantern, by trial in this way is not easy. Commandant Roussilhe, of the French Army, who has made a study of photographic

Fig. 3.



rectification, states that he can adjust his lantern in half an hour, but our experience is that it often takes much longer.

If, however, the tilt, etc., can be found independently, the positions in which to set the various parts of the lantern can be computed from fairly simple formulæ.

The tilt can be determined by a graphic construction drawn out on the map or photo, or by a computation, depending on linear measurements of the relative positions of the control points on map and photo.

Both methods are, however, rather laborious, particularly the latter, and it is doubtful if either would be any quicker than the adjustment of a lantern by trial.

To try and simplify and quicken up the determination of tilt, a special apparatus called a "tilt-finder" was constructed a short time ago by the Ordnance Survey, and an improved model is now being made by the R.A.F. at Farnborough.

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This apparatus is designed to enable the points E and *e'* in *Fig.* 1 to be found, and to enable the distance L*e'* to be measured.

To understand its working it is necessary to imagine a direct enlargement of the photo placed as at P' in *Fig.* 1. That is to say, parallel to the plate P and at a distance from L equal to the focal length LC multiplied by the scale of enlargement. If we replace the lens L by an eyehole O (*Fig.* 4), mark three control points A, B, D on the photo, and plot the three corresponding points of the map on a transparent screen S, we can place the screen S with the points on it in perspective with ABC by looking at it through the eyehole O and moving it about until we get each point on it aligned exactly on the corresponding points on the photo. The screen S will then

Fig. 4.

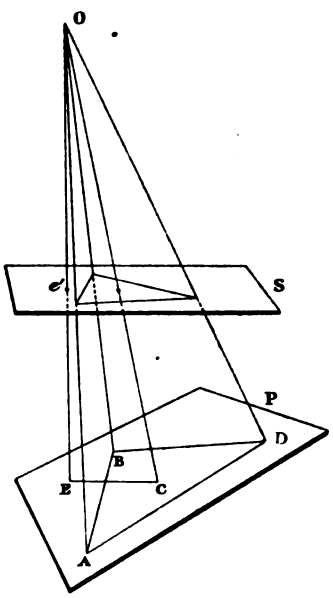
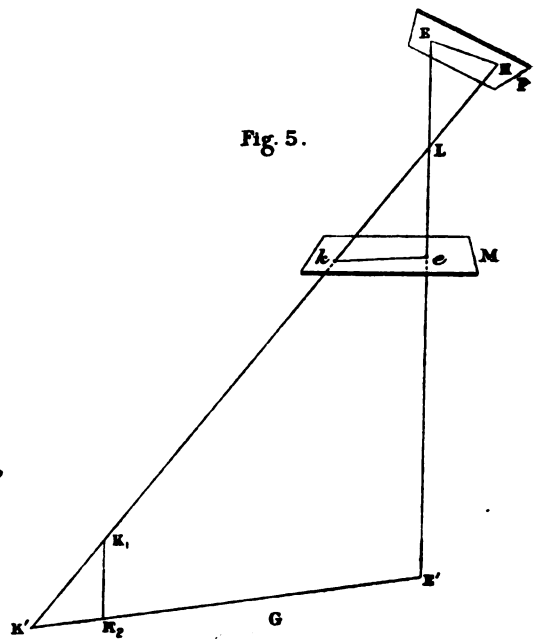


Fig. 5.



be in the same relation to O as the plane M in *Fig.* 1 is to L; we can then drop a perpendicular on to S and mark its foot *e'*. The point E on the photo will be in prolongation of O*e'* and can be marked also.

CE gives the direction of tilt EC÷OC, the tangent of the angle of tilt, and O*e'* the height above the map-plane.

The original or Mark I model of the tilt-finder is designed on the assumption that the control points are of the same height. In the Mark II model, now being constructed, the screen is replaced by a frame on which allowance for the height of a point can be made.

The mechanical arrangements are such that the adjustment of the screen can be made on a definite system, and only takes a few minutes. Such experience as is available from the use of the

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existing model seems to indicate that the apparatus is likely to be sufficiently accurate for all purposes that we can at present foresee.

If these hopes prove to be justified and we find that we can deduce tilt easily and quickly from control points of different heights, we are in a position to tackle the problem of determining position and height of points in hilly country.

In *Fig.* 5, if P is a photograph, M a print of it in which tilt distortion is eliminated, K_1 a point on the ground, and ELE' a vertical line through the lens. It can be seen that *ek* is the undistorted image of EK and gives the length and direction of E'K to the map scale $\frac{Le}{LE'}$.

When we have found *e*, we can plot the line *ek* in its correct position on the map and know that it passes through the map position of K_1, which is the point corresponding to K_2.

If we take another photo of K_1 from some other view-point, we obtain another line passing through this position, which is determined by the intersection of the two lines.

Again, since we know the relative positions of E, K and L, we can determine the angle ELK, and consequently the angle $K_1K'K_2$.

The distance corresponding to $K'K_2$ can be found from the plotted line *ek*, and the height K_1K_2 can be computed.

In theory, therefore, if we can measure tilt and rectify each photo, we can determine position and height of any point from two photos.

We have not actually tested these principles in practice. No doubt it would be a laborious job to plot an area point by point in this way.

It is not very likely, however, that this will be necessary.

We might be tempted to condemn the plane table as a method of survey on similar grounds, did we not know that the plane tabler fixes instrumentally only sufficient points to control a drawing which he does by eye alone.

We will probably be able to proceed in a similar way with aerial photographs, because, if the photos are taken in a suitable way, we can view them in a stereoscope and see the relief of the ground quite distinctly.

The "stereoscopic" principle may be applied also to instrumental methods of fixing points. It has been exploited for this purpose in Germany, where the firm of Heyde in Dresden have made a machine, analogous to the "Stereoplotter" invented by the late Major F. V. Thompson, R.E., to the specification of Professor Hugershoff of Dresden University, for mapping from stereoscopic aerial photographs. The firm of Zeiss are believed to be working out details of a similar machine.

In this machine "Vertical" photos are not used. The aeroplane camera is hand-held and pointed out to the side of the aeroplane.

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By means of a bubble on the camera the optical axis is held at an angle of approximately 30° below the horizontal. The aeroplane flies at a height of about 1,000 metres and photos are taken as nearly as possible parallel, at intervals of about 1 km. It is assumed that the foreground of these photos can be made to include three or more control points on each (the inaccessible area appearing in the background only), and Professor Hugershoff has worked out a method by which the position in space of the camera and the direction of the optical axis can be computed from the positions of these points on the negative.

This computation is rather a formidable affair, but, once it has been done, the machine can be set in adjustment, diapositives of the negatives placed in the stereoscope, and the map drawn in quite mechanically, both as regards detail and contours.

The machine is very large and heavy (I would estimate its weight as at least 5 tons) but is not as complicated as might be imagined. It is, however, very costly. The price asked by the firm being about £10,000.

The makers claim that it is really an instrument of precision and to vindicate their claims have offered to produce from photos taken by us in England, of an unspecified area, a map which we can compare with our Ordnance Maps of the same region.

This offer has been accepted by us; the aerial camera is now in England and a number of photographs have been taken with it for dispatch to Germany.

Until this trial is complete it would be premature to venture an opinion as to which of the methods described will eventually prove of most practical value.

Sufficient has been said, however, to show that in theory, at least, aeroplane photography can supply all the data required for preparing maps of country up to, let us say, 20 miles behind an enemy's front line.

There are in existence a few civil firms engaged in aerial photography with a view to mapping, but it is believed that the maps produced by them make no claims to great accuracy.

The photos are simply built up into "mosaics" without any attempt to eliminate distortion. The whole is then rephotographed and enlarged or reduced to some particular scale determined independently.

This is essentially the method of mapping developed in Palestine and Mesopotamia, and of which the principal exponents are now Capt. Hamshaw Thomas and Professor Melvill Jones of Cambridge University.

For this type of work, depending on the adjustment of a complete "mosaic" and not on that of single photos, it is important that the tilt of the aerial camera should be as small as possible. Professor

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Melvill Jones has accordingly carried out a considerable investigation into the possibilities of level flying, and has shown that under peace conditions it is possible to train pilots to fly so that the camera will remain within a degree of the vertical all the time.

Whether it will be possible to do this under war conditions is another matter. In any case, however, whatever may be the success of this method for civil work, and it must be admitted that for many purposes a map prepared in this way is all that is required, we must not be led into thinking that it will do for a tactical map.

For war we require not only completeness of detail, but a high standard of accuracy, and, above all, heights and contours.

To determine heights it is probable that a photo tilted to 20 or 30 degrees from the vertical will be more useful than one only half a degree from it. I think it is evident that, apart from other considerations, the question of contours alone must lead us on to try and perfect one or other of the methods and systems I have described, and I venture to think it is quite time that we set about giving them really practical and comprehensive trials, even though these may cost a little money.

The theory of the subject is fairly complete, but in view of the importance of the time-factor in war, we have not only to decide what method to use but also to devise and construct apparatus for it with which we can practise till we can work it quickly, so that we can produce the map in time in the first instance and keep it always well up-to-date afterwards.

The situation at the present time may be summed up thus :—

"We believe that in the aerial photograph we have a means of mapping country up to at least 20 miles behind the enemy's front line.

"We cannot, however, yet guarantee that the results will be up to standard of accuracy required, nor can we give any idea of how long it would take to produce them.

"We are not yet in a position to say what sort of equipment would be required or how many men would be necessary to work it."

We cannot, therefore, yet count on being able to produce an accurate large-scale map in sufficient time, but I think the prospects of being able to do so are quite good enough to justify our devoting both time and money to experimental work for this object.

Experimental work and research is carried out, as mentioned by Col. Winterbotham in the last number of the *R.E. Journal*, under the direction of a Committee composed mainly of R.E. and R.A.F. officers.

Lack of properly thought-out equipment has, so far, prevented this Committee from getting on very far with the practical side of the subject. It has, however, gone pretty fully into the theory and has initiated the construction of such equipment as it has been

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possible to make with the funds available. When this equipment is ready for use one may hope for more rapid progress.

The Committee also endeavours to keep in touch with what is being done by civilian departments and firms both at home and abroad.

The subject is beginning to arouse interest in a good many quarters, and several considerable surveys by aerial photography are in contemplation, from which, if they eventuate and are organized on correct lines, it should be possible to obtain useful experience.

For civil work, of course, the economic factor is of prime importance. I have not touched on it because it is really outside the scope of this lecture, and because also there are, at present, very few data from which the cost of aerial surveys can be estimated.

We cannot yet say, for example, how many hours of flying will be necessary to photograph a given area, nor have we any idea at all how long it will take to deal with the photos after they have been taken. Some estimates have been made which seem to indicate that, unless the country is particularly difficult for survey on the ground, aerial photography is not as cheap as the topographer on foot. It has, however, this advantage, that the field work can be done very quickly, and in places where the "field season" is short, this may be important. Some time or other I have little doubt that aerial photography will compete economically with existing methods, even in accessible country, but he would be a bold man who would say that this time has arrived.

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THE MADRAS SAPPERS AND MINERS.

Sapper. Havildar. Indian Officer. Bugler.

TYPES OF THE MADRAS S. & M.

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THE MADRAS SAPPERS AND MINERS.

By THE COMMANDANT.

THE CYPHER OF QUEEN VICTORIA WITHIN THE GARTER.

THE SPHINX.

A GOLDEN DRAGON WEARING AN IMPERIAL CROWN.

"Sholinghur" "Carnatic" "Mysore" "Seringapatam" "Egypt" "Assaye" "Java" "Nagpore" "Maheidpoor" "Ava" "China" "Meeanee" "Hyderabad" "Pegu" "Persia" "Lucknow" "Central India" "Taku Forts" "Pekin, 1860" "Abyssinia" "Afghanistan, 1878–80" "Tel-el-Kebir" "Egypt, 1882" "Tofrek" "Suakin, 1885, "Burma, 1885-87" "Chitral" "Malakand" "Tirah" "Punjab Frontier" "China, 1900."

"WHAT *are* these Sappers and Miners? Are they soldiers?" Such was the innocent question of a certain Major of British Cavalry, arrived for the first time in India to join his regiment, on being told that it had shortly before been defeated in the local Polo finals by "The Sappers and Miners."

The following few notes have been compiled in the hope of doing something to dissipate this mental fog (which, it is feared, obscures the minds, even of R.E. officers, who have not served East of Suez) as to the exact relationship between the R.E. in India, the Sappers and Miners, and the Indian Pioneers. These notes may also serve to inform the young officer, proceeding to the East for the first time, as to what he will encounter, if posted to a Corps of Sappers and Miners.

The Indian Sappers and Miners consist of three* Corps, the Madras, Bengal, and Bombay relics of the days when these three Presidencies maintained each its own army. Since these three Corps are entirely independent, and differ materially in history, establishment, composition and personnel, I will deal mainly with that with which I am best acquainted, the senior Corps, "Queen Victoria's Own Madras Sappers and Miners."

Historical.—It was in the year 1639, that the English first settled down in Madras. The incessant wars of the succeeding century

* There is a fourth Corps, "The Burma Sappers and Miners," which was established in 1922. It consists of a single company of Burmese, which had previously (since first raised in 1887) formed part of the Madras Sappers and Miners.

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led to the raising of the Madras army, while the atrocious roads of the period, and the numerous sieges, called for the services of a "Military Working Corps." Between 1760 and 1780, accordingly, companies of Pioneers were from time to time raised to meet special emergencies, by taking volunteers from the Infantry regiments, but disbanded again on the conclusion of the operations. In the latter year, however, this unsatisfactory system was abandoned, and two permanent companies of Pioneers made their appearance, under the following order :—

> "The Honourable the President and Select Committee are pleased to direct that two companies of Pioneers be raised as soon as possible by the Commissary of Stores, each Company consisting of 2 serjeants, 3 corporals, 5 havildars, 5 naiks and 100 black pioneers—the Pioneers to be clothed in blue jackets, and to be armed, 50 of each company with light pistols and 50 with pikes 6 ft. long. When these Pioneers are raised, they are to be employed with the army to clear and mend roads, etc."

Now, the Madras *Engineers* had come into being 10 years previously, but were merely a small* body of officers, without any rank and file to execute their orders. The pioneers were commanded, not by them, but by Infantry officers, seconded from the Madras army, who drew double pay of rank while so employed. The Pioneers only came under the orders of the Engineers when detailed to assist them in some specific work, such as a siege.

Although this was somewhat similar to the system existing in the home army till after the Crimea, the officers being "Royal Engineers," while the men were "The Royal Sappers and Miners," it could hardly have been expected to please the Madras Engineer officers, who had to work with the pioneers in war, without having been able to train them in time of peace. The following is an extract from the writings of one of them† :—

> "The only men generally available for the duties of that department (*i.e.*, The Engineers) have been the Pioneers, and as these men have never been employed in military works of this description, excepting when on actual service, it has been the hard fate of the Engineer officers to be obliged to teach them everything . . . when exposed to fire.
>
> "Poor indeed would the Sapper and Miner be considered in Europe whose skill, like that of our most experienced native pioneers, extended no further than the making of a fascine and a gabion, and having some knowledge of the nature of a

* Nine only, in 1770.

† *Sieges of the Madras Army*, pub. 1825. *By* Lieut. Lake, of the Hon'ble East India Company's Madras Engineers. Pp. 237 and 239.

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> battery. By these observations, I am far from wishing to depreciate that respectable body of men . . . every Engineer, who witnessed their exertions, must admit that they deserve great credit for having shown so much zeal . . . But the opinion of those officers . . . who maintain that the present Pioneers have always been a perfect model of a military working Corps . . . cannot be too highly reprobated."

The fact that the Pioneers were under the Commander-in-Chief, while the Engineers were under the Governor, constituted a further anomaly. The second Mahratta War (1817–19), a campaign peculiarly prolific of sieges, appears to have brought matters to a head. In 1821, the Chief Engineer (Major de Havilland, M.E.) delivered himself of a truly monumental memorandum on the subject, and a long and acrimonious correspondence ensued between him and the Quartermaster-General. The latter considered that the Pioneers were his special property, and was loth to part with so useful a Corps, which had by this time grown into two battalions, each of eight companies.

De Havilland, however, carried his point, and in 1823, the Court of Directors decided to abolish one battalion of the Pioneers, and convert the other into a Corps of Sappers and Miners, to be officered from the Madras Engineers. They assigned the following reasons :—

> "It is obvious that the utmost advantage cannot be derived from the labour of Pioneers unless it be scientifically directed, and consequently it would be for the interest of the service that the whole of the Pioneers should be put under the command and direction of officers of Engineers regularly instructed in the art of sapping and mining, making pontoons and bridges, roads and surveys, fortifications and other buildings. We have for many years, with equal care and success, and at great expense, educated young men for these purposes at Addiscombe, and it seems high time that we should reap the benefits derivable and expected from that institution."

The change was eventually carried out in 1831, and the Madras Pioneers were transformed into "The Corps of Madras Sappers and Miners," with an establishment of eight companies.* Since

* Although the original "Madras Pioneers" were thus re-incarnated as Sappers and Miners, "Madras Pioneers" still exist, since certain regiments of the Madras Infantry were converted into Pioneers in 1885. These, however, have no connection with the Corps of Sappers and Miners.

The "Pioneer Battalion" is, I believe, peculiar to India, and practically amounts to an infantry battalion trained in road-making and plate-laying. It is officered from the Indian infantry (much as were the original Madras Pioneers of 1780), though the officers no longer draw "double pay of rank while so employed."

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that date there have been few changes worth recording here. When, after the Mutiny of 1857–58, the H.E.I. Company's army was transferred to the Crown, the Royal Engineers absorbed those of the three Presidencies, and has since officered the Sappers and Miners. The number of companies in the Madras Sappers and Miners has naturally fluctuated a good deal during its existence (from a minimum of 6 field units in 1837 to a maximum of 23 in 1918), but the strength of the individual company has meanwhile steadily increased, till it now stands at 230 of all ranks, a very pleasant command for a R.E. captain.*

Organization.—As already stated, the three Corps of Sappers and Miners, although training on identical lines, differ from each other to a certain extent as regards establishment and internal economy.

Each is similarly composed of (*a*) headquarters and depôt companies, and (*b*) field units, which consist of field troops, field companies, army troops companies, divisional headquarters companies, railway companies, bridge train, printing sections, and photo-litho sections. The proportion of these various field units is not, however, by any means the same in each of the three Corps. For instance, the bridge train is peculiar to the Bengal Sappers, while the Bombay Corps has a monopoly of the railway companies, but has no field troops at all.

The present establishment by units of the Madras Sappers and Miners is as follows :—

2 Field troops.
5 Field companies.†
2 Army troop companies.
1 Divisional Headquarters company.
1 Printing section.
1 Photo-litho section.
3 Depôt companies.

—or a total of 35 British officers, 57 R.E. Warrant and N.C.O.s and 2,167 Indian ranks.

The field units of the three Corps are not all congregated at the headquarters of their Corps any more than those of the R.E. are all massed at Chatham; each Corps has so many "out-stations" allotted to it, and its field troops and field companies occupy these in rotation on a two or three years' tour. The Madras Sappers and and Miners (for example) have one field troop in Sialkot, and two field companies in Waziristan, places at the other end of India, and some 1,500 miles from its headquarters at Bangalore.† The field

	B.Offrs.	B.N.C.O.	I.Offrs.	I.N.C.O	I.R.&F.
*Est. of S. & M. Co., 1831 ...	1	1	1	7	80
,, ,, 1923 ...	2	2	4	22	200
Est. of whole Corps, 1831 ...	10	10	8	57	640
,, ,, 1923 ...	35	57	47	307	1813

† There is also at present a 6th Field Company in Iraq, earmarked for eventual disbandment.

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company Sapper may in peace time, therefore, expect to average two years at headquarters for each year at an out-station. The remaining field units are located at headquarters in time of peace for the sake of the training in the Corps workshops, but are allocated to war divisions, and join them on mobilization being ordered.

" Headquarters " consists of a Commandant (Lt.-Colonel, who is also the C.R.E. of the War Division to which the field companies of his Corps are allotted) ; two Majors, responsible respectively for workshop and fieldworks training ; an Adjutant, who deals *inter alia* with recruiting ; a Quartermaster ; and some 20 R.E. Warrant and N.C.O. Instructors. Each Corps is entirely independent of the others, and carries out its own recruiting, training and administration, and its headquarters (located respectively at Bangalore, Rurki and Kirkee) is consequently a miniature S.M.E. At headquarters also are the three depôt companies, the first composed of Indian instructors, storekeepers and " employed men " generally, the second a " pool " of trained men ready to replace casualities in the field units, while the third consists of recruits in various stages of training.

Training.—The Madras Sappers differ very greatly from the British R.E. in the fact that they are recruited almost entirely from unskilled labour, recruits with " ready-made " trades being practically unobtainable. This is partly due to the fact that in India handicrafts (such as carpentry, etc.) are hereditary occupations, whose exponents are rarely of the military classes ; partly also to the fact that in India any sort of an artisan can get far more pay in civil life than in the army. The Sappers and Miners are accordingly obliged to draw their men from the vast agricultural population, and make shift to teach them trades after enlistment. It is mainly for this work of trades instruction that the R.E. Warrant and N.C.O.'s are maintained. It will be realized that having to teach the Indian ploughboy to become *both* a soldier *and* a craftsman is rather a larger proposition than that confronting the Training Battalion at Chatham, which counts on catching its recruits already grounded in some trade.

Accordingly, the training of the Sappers and Miners recruit is a somewhat lengthy process. In the Madras Sappers it is reckoned to take two years to turn out a reasonably efficient sapper. In the first year he is classed as a recruit, and does six months' drill and musketry, followed by six months' fieldworks. At the beginning of his second year he is told off to a trade and begins his instruction therein in the Corps workshops. In the course of this second year he is expected to become, at least, a " 2nd-rate " tradesman,* and fit for posting to a field unit. His trades instruction, however, continues unabated throughout the whole of his service, his normal year working out roughly at one month's musketry, three months'

* There are 6 rates, " A," " B," " C " (artificers) and " 1," " 2," " 3 " (ordinary). The 3rd rate is the " labourer " rate.

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fieldworks, and eight months in the workshops. This last is not, however, nearly as much as it looks on paper, since guards, furlough, manœuvres (to say nothing of the numerous religious and other holidays given the Indian soldier) make a pretty good hole in it, and the average man does not in practice get more than 80 to 100 days in the workshops in the year.

For the training in drill, musketry and fieldworks the Company Commander is always responsible, whether the unit is at headquarters or at an out-station. Also for trades instruction in the latter case, each detached unit being provided with some sort of workshops, and having its two R.E. N.C.O.'s as instructors. At headquarters, however, the whole of the trades instruction is concentrated in the hands of one of the two Majors, who is assisted by a staff of R.E. Warrant and N.C.O.'s representing all the trades concerned.

The relation between the R.E. Warrant and N.C.O. and the Indian officers of the field units is that the former are (in the Madras Sappers and Miners, anyhow) entirely instructors, and have no disciplinary powers. There has to be a good deal of "give and take" between the two, and it requires the exercise of some tact on the part of the British officer to prevent them from clashing at times.

Personnel.—The personnel of each Corps consists of British officers, R.E. Warrant and N.C.O.'s, Indian officers, Indian N.C.O.'s and and Indian sappers.* The British officers and R.E. Warrant and N.C.O.'s are naturally much the same in each case, but the Indian ranks are markedly different, since the three Corps recruit from widely diverse classes of men.

Those who have not served in India may, perhaps, not realize that Bangalore, the Headquarters of the Madras Sappers and Miners, is about the same distance from Rurki, that of the Bengal Corps, as Madrid is from Berlin, and that the men enlisted by the two are racially, linguistically, and in appearance, at least, as far apart as Spaniards are from Prussians.

The Madras Corps draws its recruits from the great Tamil race of South India, which follows several religions and is divided into a variety of castes. The "caste composition" of the Madras Sappers and Miners varies slightly from year to year, but averages out at :—

Mahomedans	10 per cent.
Hindus	40 ,,
Parayers	27 ,,
Christians	13 ,,
Other castes	10 ,,

* Although the Indian ranks of the S. & M. naturally belong to the Indian Army, the British ranks do not. The W. & N.C.O. of the Madras Sappers are officially known as the "Bangalore Detachment, 'H' Company, R.E.," and both they and the British officers come under the same regulations as men of British regiments serving in India.

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No hard-and-fast composition by races or religions has, however, been imposed on the Corps, and the Commandant is at liberty to recruit them in any proportion he pleases.

The name " Parayer " may, perhaps, require explanation. This Tamil word

> " is the original from which the English " pariah," or outcast, is derived, and is an unfortunate name for a class which contains a large proportion of intelligent, strong, hardworking men, who make excellent soldiers and sappers. Outcasts, or rather ' out of caste,' they certainly are from the Brahmin's point of view ; but as they form the majority of the population, and are its most useful members, there is no reason why any European (himself, by the way, just as much an ' out caste ' to a Brahmin) should consider them as such. . . . They come from cultivating the soil in Arcot, from working on the railways, from gold mining at Kolar, or from the rice fields everywhere. They seem to have in them something of the spark of roving energy so seldom found in the native of India, but which is an invaluable military quality. . . . In fighting spirit the Parayers are second to none of the other classes enlisted by the Corps ; and it is largely to them . . . that its excellent reputation for hard work and hard fighting is due."*

The Parayer and the Indian Christian are closely allied, since the ancestors of most of the Indian Christians were Parayer converts. The name " Indian Christian " is unfortunately one of evil savour to the European of Northern India. This is possibly due to the comparative recency of the conversions there, converts of the first generation being sometimes open to suspicion as to their motives. In South India, however, there have been Catholic Missions for several hundred years, and the Indian Christian has had time to settle down and develop into as useful and self-respecting a community as any other. However that may be, the Indian Christians provide the Madras Sappers with some of its best recruits—men who are as trustworthy, brave and hardworking as the rest of their comrades, while usually a good deal better educated and more intelligent.

This question of castes and religions brings us naturally to a matter in which the Madras Sappers and Miners differ fundamentally from the other two Corps, and, indeed, from the whole of the rest of the Indian Army. This is its practical non-recognition of caste. The caste or religion claimed by a recruit is, it is true, duly entered in the appointed place on his attestation paper, but there the matter

* *The Characteristics of the different Types of Men in the Q.V.O. Sappers and Miners.* By Captain E. K. Molesworth, R.E., 1907.

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ends, as far as the Corps is concerned. Mahomedan, Hindu, Christian and Parayer stand shoulder to shoulder in the ranks, live together in the same barrack room, and eat the same food from the same cooking pot.

It must be understood that this happy state of affairs is not by any means typical of the Madrasi as a whole. The Madras Infantry regiments, which recruit much the same material as the Sappers and Miners, are just as caste-ridden as any others of the Indian Army. It is solely due to past generations of Sappers and Miners officers having always refused to allow the intrusion of caste into service matters, till in the end its non-recognition became a Corps tradition. As Gen. Sir Harry Prendergast, V.C., G.C.B., wrote over 40 years ago :—

> "If you ask a Sapper about his caste, he will probably say he is 'sapper caste,' that is, he is first a Sapper and next a Mahomedan or Hindu."*

Another writer, a former Adjutant of the Corps says :—

> "So little do caste prejudices affect the Q.V.O. S. & M., that very often one man does not know the caste of another in his own Company."†

This results in a broadmindedness and toleration, unusual in an Indian. In the Madras Sappers the Hindus, Christians and Mahomedans actually subscribe towards, and take part in, each others' religious jollifications, such as the Dasara, Christmas, and the Mohurram. This characteristic is well described by Gen. Prendergast in the person of Subadar Seeloway, who received the Order of Merit for gallantry in the Mutiny :—

> "Seeloway was a typical Sapper, very black, with a good-natured, ugly face. He was a good disciplinarian, and insisted on being treated with due respect. A Hindu by descent, he would enjoy a Hindu feast; a Christian by conviction, he appreciated Christians' cheer, and, being liberal, he joined in Mahomedan festivities."‡

It is hardly necessary to expatiate on the convenience of such an economy, compared with the usual system of caste segregation as observed in the rest of the Indian Army. In the Madras Sappers, for instance, the best man is always taken to fill a vacancy, whatever his caste or creed. In other Corps, however, a Hindu vacancy has to be filled by a Hindu, even were there a dozen more deserving

* *Life of General Sir Harry N. D. Prendergast*, V.C., G.C.B. (Vibart), p. 157. Gen. Prendergast was Commandant of the Madras Sappers from 1869 to 1880.

† Capt. Molesworth.

‡ *Prendergast*, p. 158.

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Mahomedans available. In the Madras Sappers, in fact, "The *man* is everything, the *caste* nothing."

Possibly owing to his daily contact with the R.E.N.C.O. instructors in the workshops, the Madras Sapper has developed several curiously English habits, rare in the rest of the Indian Army. He astonishes officers from North India by having a canteen, where he may daily be seen sitting at a table, smoking a short pipe, and enjoying a mug of beer. He is well known for his proficiency in English, a very desirable qualification in a sapper, who has to work with British troops. He is astonishingly friendly with the latter, too :—

> "During the Mutiny campaign, the comrades of the Sappers were not the native Indian regiments of the same brigade, but the 86th Royal County Downs. At Larnaka in Cyprus 20 years later there was a special friendship between them and the bluejackets."*

A historic friendship has existed since 1843, between the Madras Sappers and the 22nd Foot (now the Cheshire Regt.). This had its birth at Meeanee, in which battle the two fought side by side.

Another curious custom of the Madras Sapper, in which I believe he is again unique in the Indian Army, is his habit of referring to himself and his comrades by their regimental numbers, instead of their names. For instance, a sapper s name may be Venkatasaperumal, Gnanapragasam or Abdurraham Khan, according to his caste and creed, but if his regimental number is (*e.g.*) 1516, he will invariably be addressed as "Fifteen Sixteen," and as "Sixteen" *tout court* by his familiars. Strangely enough, this custom only maintains in the ranks ; when a Havildar is promoted to Indian officer, he resumes his name.

The Madras S. & M. has always been an essentially long service Corps. Enlistment is originally for four years only, as in the rest of the Indian Army, but very few men claim discharge at the end of their engagement. The small pension granted after 15 years' service is, no doubt, an inducement, but even after qualifying for this, the majority still serve on until turned out on completion of 21 years in the ranks. The Indian ages early, and experience has shown that after 21 years of the arduous life of a sapper the average man is too old for service in the field units.

Fortunately, the pensioned sapper is in considerable demand by employers of labour, and he may be met all over South India in such jobs as foreman, storekeeper, watchman, policeman and forest guard. Many pensioners obtain employment in the large town of Bangalore, and settle down there permanently with their families. There is thus a strong colony of ex-sappers living round the headquarters of the Corps, and this produces many excellent recruits.

* *Life of General Sir Harry N. D. Prendergast*, V.C., G.C.B., p. 158.

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Some families, indeed, can claim to have served in it, father and son, for three and even four generations.*

Perhaps in this connection it should be explained, for the benefit of the reader in England, that Bangalore stands in the Indian State of Mysore, and is a considerable distance from the normal recruiting ground of the Corps, which is British Madras. The inhabitants of Mysore are Canarese, a race quite distinct from the Tamils, talking a different language, and of no value as soldiers. It is much as if the Headquarters of the Royal Engineers was still located at Chatham, but recruited only Welshmen, either direct from Wales, or from a Welsh colony of ex-sappers settled round the S.M.E.

From the point of view of the British officer, the Madras S. & M. is extremely fortunate that its Headquarters are placed, not in the stifling plains of Madras, but on the table-land of Mysore, some 3,000 ft. above the sea, with a delightful climate all the year round.

Services.—Of the services of the Corps between 1780 and 1922, what shall be written? Are not the more notable already recorded by its thirty-one† official "Battle Honours," as shown at the head of this article? Few other Indian Corps can claim to have left their dead in places as far apart as Mauritius and Lhassa, Lagos and Pekin. The Corps collection of medals shows that out of the 42 distinct medals awarded for services in all parts of the world, between 1780 and 1922, which it has been possible for *any* Indian troops to receive, the Corps has qualified for no less than thirty-one. Its mentions in Orders and Dispatches would fill a fat volume, so the following must suffice as interesting examples:—After the "First War in Burma (1824–26)," the last which the Corps attended as a battalion of Pioneers, their services were acknowledged in the following General Order:—

> "To mark the high sense which the Government entertain of the indefatigable exertions of the Corps of Pioneers throughout the war in Ava, the Honourable the Governor in Council is pleased to resolve, as a special case, that Jemadar Andoo, of that Corps, whose gallant conduct has been particularly brought to notice, shall be promoted to the rank of Subadar, that he be presented with a palankeen, and an allowance of Rs 70 monthly for the support of that equipage, and that a

* An excellent example of the hereditary S. & M. family is that of Subadar Seeloway (*vide* page 264). Seeloway served from 1823 to 1860, dying as a Subadar. His son, Chinnapen, served from 1855 to 1880, and rose to be Colour Havildar Major. *His* son, Maricruz, served from 1884 to 1919, and retired as Subadar-Major. The fourth generation is represented by three sons of the latter, now serving in the Corps, one being a Jemadar and two Lance-Naiks.

† No "Honours" for the war of 1914–18 have yet been awarded to Indian Troops, at the time of writing.

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pension of half pay be granted to his nearest heir after his decease."

The War in Coorg of 1834 was the first considerable operation attended by the Corps in its rôle of Sappers and Miners, and to this it sent five out of its eight companies. On the conclusion of the operations, a Court of Enquiry was held " to ascertain the claims of certain native soldiers of the Madras Army, reported conspicuous for gallantry," and reported that " Havildar Chokalingham, of the Corps of Madras Sappers and Miners, has satisfactorily established pretensions to eminent bravery." The Governor General, then, " as a mark of the high sense he entertains of the distinguished conduct of that non-commissioned officer, is pleased to confer on him an honorary medal,* and an increase for life of one-third of his present pay."

In the suppression of the Mutiny of 1857–58 (which, it must not be forgotten, was one of the *Bengal* Army only) the Madras Sappers had three companies engaged, " C " Company at the Relief of Lucknow, and " B " and " L " Companies in Central India. Of the first it is recorded :—

" The Madras Sappers were in the van of the advance, blowing open the gates, and breaching the walls of the fortified buildings that blocked the way. They were the first to hoist the British flag on the roof of the Martinière. After the relief of the Residency they were left with Sir James Outram's force at the Alumbagh, and took the chief part in the fortification of his position, working all day and every day, and sometimes all night also."

The same author† writes of the companies in Central India :—

" The ' B ' Company had been engaged in the Persian War, and had just returned from the Gulf to Bombay, when the Mutiny broke out in Bengal, and the Madrasis at once volunteered for service against the mutineers. . . . It took part in all the sieges and battles of that brilliant campaign, serving as infantry in the line of battle when there was no work to do in its own special line. . . . The Company was in action eighteen times in the field and in the assault of fortified places, besides being constantly under fire during siege operations. . . . Two of its native officers and five of its

* This medal (which is quite unique) is in the Corps' collection at Bangalore. Chokalingham rose to the rank of Subadar, and when the " Order of British India " was founded in 1838, he was admitted direct to the First Class, being thus the first native officer of the Madras Sappers to attain that honour.

† *The Services of the Madras Native Troops in the Suppression of the Mutiny of the Bengal Army.* (Tyrrell) p. 26.

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rank and file were admitted to the 'Order of Merit*' for bravery in this campaign. The 'B' Company took the field with six European officers and 120 native officers and soldiers, and it returned to Madras with a strength of 40 of all ranks, commanded by a junior subaltern, after twenty months of continuous service in the field."

"Overseas" jobs have fallen much more to the lot of the Madras Sappers than to either of its sister Corps. Its companies have attended all three of the China wars, and have been no less than five times† to Egypt or the Soudan. One of its most valued honours was gained in the latter country, at Tofrek,‡ near Suakin, in 1885, where "F" Company threw itself into the broken face of the square, where a Bengal infantry regiment had given under the Arab rush,§ and indubitably staved off a very serious disaster to the British arms. In so doing the Company lost of its three British Officers, two killed and one wounded, and suffered over 30 casualities among the some eighty Indian ranks present.

In the Great War of 1914–18 the Corps increased its establishment from 6 field companies to 3 field troops and 20 field companies, and served in France, Egypt and Palestine, Mesopotamia and Persia, East Africa, and on the Indian Frontier.

A certain distinguished General told the writer the following story of his first meeting with the Madras Sapper:—It was in the early part of the war in France, and a somewhat impromptu retirement of our line had taken place. He, being then a Staff officer, was making his way warily round the abandoned position, when he came upon an Indian N.C.O. and some men, whose appearance was strange to him. "Who are you?" he asked in surprise, as the spot was far from healthy, "and why have you not cleared out with the rest?" The havildar replied simply, "We are the Queen's Own Sappers and Miners, Sahib, and we have not had the order to retire." This apparently struck the Staff officer as remarkable.

The bulk of the Corps, however, served in Mesopotamia, where two of its companies bore a distinguished part in the crossing of the Tigris at Shumran in 1917:—

"On the night of 22–23 February, under cover of darkness, the three columns advanced to their respective points on the river, pontoons were off-loaded by the sappers, and carried

* In the Indian Army the "Order of Merit" was the equivalent of the Victoria Cross, for which Indians were not eligible before 1911. In the Mutiny the three companies of Madras Sappers managed to secure no less than eleven "Orders of Merit" between them.

† Expedition under Gen. Sir David Baird, 1801. Tel-el-Kebir, 1882. Suakin, 1885. Suakin, 1896. Egypt and Palestine, 1914–18.

‡ Also known as "McNeill's Zariba."

§ *My Service Days* (General Sir Norman Stewart), p. 122.

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as close as practicable to the water's edge. Just before dawn on 23rd February, all pontoons were simultaneously launched, and ferrying commenced.

"At the centre ferry (run by No. 12 Field Company) the pontoons came under heavy fire from a Turkish picket and machine-gun on the far bank when about three-quarters way across. Three pontoons were knocked out and ten reached the far bank. Of these, eight returned for a second trip, being heavily fired upon the whole time. In an hour and a quarter 150 men of the 2/9th Gurkhas with four Lewis guns were ferried across and established on the far bank. Only four pontoons now remained in action . . . Casualties among the rowers were very heavy, many of the crews being completely wiped out.

"At No. 3 ferry (run by No. 13 Field Company) the pontoons came under heavy fire from a Turkish picket when about half way across, and were enfiladed by a machine-gun. Many casualties occurred among the rowers, but six pontoons managed to return for a second trip. After three-quarters of an hour, eleven pontoons were out of action, and only two remained. By this time 100 men of the 1/2nd Gurkhas with four Lewis guns were across and established on the far bank."*

Although it is not well to blow overmuch even the trumpet of one's own Corps, I cannot resist concluding with a quotation from the writings† of Field Marshal Lord Wolseley, who had seen the Madras Sapper in Burma, in the Mutiny, in China and in Egypt :—

"The best native soldiers, taking them all round, whom I ever served with in India were the Madras Sappers. Their coolness under fire, indifference to danger, and their pride of regiment, marked them on all occasions as first-rate soldiers."

Emanating from such an authority, this is probably the most valuable of the many testimonials standing to the credit of "Queen Victoria's Own Madras Sappers and Miners."

* *Historical Record of the Q.V.O Sappers and Miners*, vol. II, p. 10-11.

† From an Article entitled *Courage*, in the *Fortnightly Review*, of August, 1888.

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DESCRIPTION OF THE WAR MEMORIAL

ERECTED BY THE Q.V.O. MADRAS SAPPERS AND MINERS AT BANGALORE.

(*Furnished by the Commandant, Q.V.O. Madras Sappers and Miners.*)

THE Memorial is constructed of grey Mysore granite, and consists of a hexagonal platform 60 ft. in diameter, raised two feet above the ground, and ascended by four steps. In the centre of this platform is a hexagonal plinth, surmounted by an obelisk, the whole reaching a height of 30 ft. The six faces of the plinth bear polished granite panels devoted to the theatres of war in which the units of the Corps served, *i.e.*, France, Egypt, Palestine, Mesopotamia, Persia and East Africa. On each panel are engraved the titles of the troops and companies which served in that particular theatre, followed by the names of the officers and men of these units, who lost their lives therein. The obelisk surmounting the plinth is a monolith of granite, weighing over ten tons.

At each of the six corners of the lower platform is a granite pedestal, about 4 ft. high, bearing a small panel inscribed with the battle honours of the Madras Sappers (31, exclusive of the late War, for which none have, so far, been awarded to Indian Troops), and surmounted by the stone figures of a sphinx, a dragon, or an elephant. These figures represent the badges awarded for the campaigns of Egypt, 1801; China, 1842; and Assaye, 1803, in all of which the Corps served.

The Memorial was commenced in October, 1919, and completed just three years later, practically entirely by the hands of the men of the Madras Sappers. Its construction was much delayed by the Afghan War of 1919 (and subsequent frontier troubles) and by the rebellion of 1920 in Iraq, to all of which the Corps had to dispatch units.

The cost was defrayed by subscriptions from all ranks, and amounted to just under Rs.15,000, or about £1,000.

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WAR MEMORIAL ERECTED BY THE Q.V.O. MADRAS SAPPERS & MINERS AT BANGALORE.

The Memorial.

Seen Across Ulsoor Tank.

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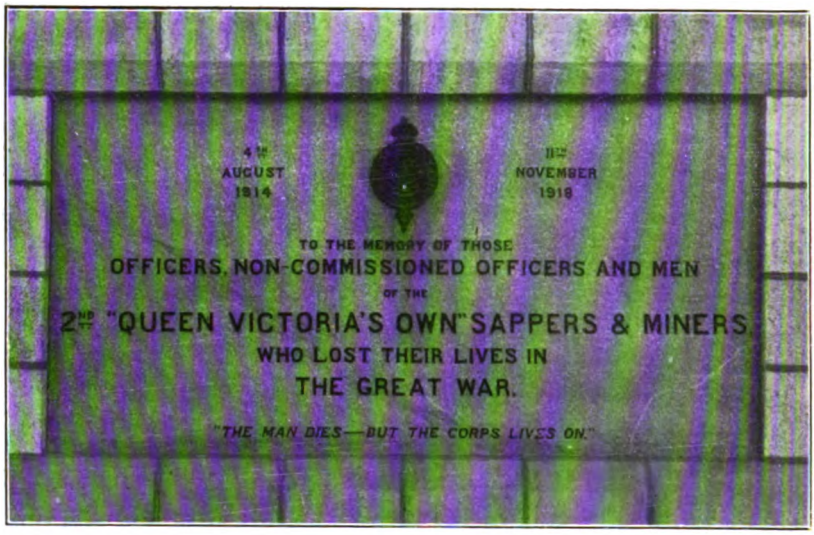
4TH AUGUST 1914
11TH NOVEMBER 1918
TO THE MEMORY OF THOSE
OFFICERS, NON-COMMISSIONED OFFICERS AND MEN
OF THE
2ND "QUEEN VICTORIA'S OWN" SAPPERS & MINERS
WHO LOST THEIR LIVES IN
THE GREAT WAR.
"THE MAN DIES—BUT THE CORPS LIVES ON."

The Front Panel.

MESOPOTAMIA AND PERSIA
INF. FIELD TROOP, NOS 9 12 13 61 62 65 86 FIELD COYS R.E. 7 BRIDGE TRAIN M.I. 3 PRINTING SECTN
KILLED IN ACTION
2ND LIEUT A.A. GARDINER R.A.F.
—— A.W. THOMAS ——
—— O.W. MAUNSELL ——
—— W.O. CARRETT ——
No. 4666 SAPR MARIMUTTU No 2 F.C.
— 36 — MUNISAMI —
— 2842 HAVR KUPPUSAMI No 12 F.C.
— 2953 — CHINNASAMI —
— 3695 — KANDASAMI —
— 4453 L/N MUTTU —
— 4275 — CHINNASAMI —
— 4461 — MARIADAS —
— 4450 SAPR CHINNAPPAN —
— 3793 — VENKATASAMI —
KILLED IN ACTION
No. 4769 SAPR PONNURANGAM No 12 F.C.
— 176 — NARAYANA NAIR —
— 3052 HAVR NARAYANASAMI No 13 F.C.
— 3435 — ABDUL KARIM —
— 4167 L/N CHINNAPANIKAR —
— 4112 — MECARAJU —
— 4187 — MADURAIVASAGAM —
— 4516 SAPR DHARMAN —
— 4308 — LOORTHANADAN —
— 76 — PERUMAL —
— 4351 — PONNAN —
— 4044 — ARUNACHALAM —
— 4131 — PONNUSAMI —
— 3684 — POONJOLAI —
KILLED IN ACTION
No. 3508 SAPR BASTIAN No 12 F.C.
— 4605 — PERUMAL —
— 4585 — SUBRAHMANI —
— 4346 — ABDULLA KHAN —
— 2764 — KUPPUSAMI —
— 2716 — CHINNASAMI —

One of the Five Panels of Names.

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BORING IN PALESTINE.

MR. A. W. DAWSON, F.S.I., has presented to the R.E. Library a copy of a lecture by Captain Paul H. Mangin on the subject of Boring in Palestine, which was read at a recent meeting of the Institution of Petroleum Technologists. The lecture describes fully the extraordinary difficulties, due to the treacherous sands and the absence of suitable plant, which were met and overcome by these officers when serving with the Royal Engineers in Egypt and Palestine, and will be read with interest by all those who require information on this most important subject, which is necessarily treated in no great detail in the volume on *Water Supply in Egypt and Palestine* of the *Work of the Royal Engineers in the European War* series.

The following contribution to the discussion by Dr. Hume is reproduced in full, as being of exceptional interest to the study of the water supply problem of this campaign :—

" It was my privilege to study the water operations from their first inception on the Suez Canal to the time when there was the long wait along the line at Gaza. It may be of interest broadly to state the conclusions arrived at in the course of the advance, these forming the basis of subsequent operations.

" In 1915 the line of defence was on the Suez Canal, and the military authorities felt the need of water supply for the troops occupying the desert side of the canal. The writer did not expect much success from boring operations undertaken here, as these were mainly sunk in the lagoon or lake formations connected with the Mediterranean and Red Sea respectively. His only hope was that water filtering through from the run-off of the Sinai Hills might improve the brackish water supply. The tests proved that no such help was afforded, and all the bores were abandoned.

" As dunes are notably good water-collectors, he then suggested that boring operations should be conducted in the dune region some little distance east of the canal, and personally selected a position in front of the line at Katib el Aruk. Here the results proved more favourable, and the water was sufficiently good for animals, and just drinkable by men. So far as the writer knows, this plan was widely developed, and enabled the line to be maintained some distance inland of the canal itself. In this sand-dune water the salt was about 2,500 parts per million.

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"A suggestion was also made to endeavour to tap the gravels of the ancient Nile arms which passed Pelusium, and to this end a bore was sunk at Mehemdiya in close proximity to a sand-dune region, but the water obtained was practically sea-water.

"In the course of the investigation the interesting point came out that in the sand-dune areas there seemed to be a layer of fresher water resting on a more salty one at sea-level.

"In the original reports made by the writer to the military authorities it was stated that the most noticeable feature proved was the existence of a water-table of wide extent at or near sea-level. Bir Mahadat, Bir Abu Aruk (*Bir* means "well") proved to be all in this position. The water-table where it reaches the sea border is represented either by marsh, gypsum swamp, or palm grove depressions (as at Romani, Katia, etc.). It was broadly concluded that along the Mediterranean border water of some sort could be met anywhere at zero level. Thus, if any point were, let us say, 100 ft. above sea-level, the depth of the well required to reach water would be about 100 ft. As regarded quality, the nearer the water was to the lagoons or sea border, the greater its salt content. One could, in fact, divide the underground water into zones of diminishing saltness, which were more or less parallel to the borders of the great lakes (Menzala and Bardawil). The quantity of water was small at any one spot, but, by tapping it at many localities, a large army was maintained on the Romani line many miles to the west of the canal over a considerable period.

"The next study of importance was in connection with the El Arish area, which the writer was invited by the military authorities to visit within a week of its occupation. Here it was evident that the rainfall absorbed by the sand-dunes and that flowing from the hills by the great drainage line of Wadi-el-Arish had given rise to a most favourable area of water-supply, the best water, as in the previous case, being tapped when sea-level was attained.

"It was calculated that the rainfall absorbed by the dunes would, if tapped by borings near their base, supply some 120,000 gallons per day. A total of 300,000 gallons per day was required for the troops on the spot, and this was obtained by boring to the east of the Wadi-el-Arish, and in the bed of that valley.

"A notable feature was the excellence of the water close to the sea coast. This is true for the sand-dune area bordering the sea in the Nile Delta, and also for a similar region west of Alexandria.

"Broadly speaking, such good supplies may be expected where a great drainage line carrying fresh water descends from the hills, especially if, at the same time, there is a water-collecting sand-dune area near the shore to strengthen the supply.

"The importance of these shallow bore operations will be realized when it is remembered that nearly 150,000 men and 100,000 animals

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(horses, mules, camels) were maintained at this spot throughout a long period.

" During the French expedition, Reynier's far smaller army found itself in a difficult position owing to the exhaustion of the existing wells, and was totally ignorant of the excellent supplies which lay close to the surface. The Germans and Turks seem to have been ignorant of the rich store of water thus available, and it will always stand to the credit of the Egyptian Expeditionary Force that it worked its advance on a basis of continuous study with striking results.

" The writer had again the privilege of being invited to examine and report on the question of water supply for the Wadi Ghuzze line held by the Army to the west of Gaza.

" Here the rules already laid down applied to the obtaining of the water from the sand-dunes, on which the left wing of the British Army largely depended.

" As regards the centre and right wings, a new and important fact came into play. An examination of the springs at Shellal, Essani, etc., proved that a second great source of water supply for the Gaza front was found in the valley deposits, the water being carried in gravels derived from the erosion of the limestone hills to east and south-east. This water was protected from evaporation and diffusion by overlying and underlying clays. As those camped in these parts learnt by sad experience, the quality of the water was less good than that of the consolidated dunes, and the gallant men on this portion of the line had to drink water which, under ordinary circumstances, would be regarded as unsuitable for human consumption. Nevertheless, these limestone-derived waters played a most important part in enabling the British Army to maintain its grip until the decisive advance took place."

F.E.G.S.

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UNARMED DEFENCE.

By TWO SAPPER OFFICERS.

SOME time ago one of us said to the other: "The French action in the Ruhr promises to be an important and interesting experiment. If France fails to get anything out of Germany, will it not show that, under modern conditions, an army is no use against the passive resistance of the civilian population of an enemy state? If Germany, unarmed, can repel the armed invasion of France, will it not show that armies are not required for successful defence? The pacifist will then say that armies are impotent in aggression and unnecessary for defence; that the surest defence for a state is its defencelessness; that armies are therefore useless and expensive encumbrances; 'Away, then, with armies!'"

Such a line of argument is, on the surface, extremely plausible, but we knew that there must be a fallacy in it somewhere. Further cogitation on the part of us both has, we think, enabled us to discover some of its failings and to arrive at certain conclusions on matters of general interest. We think that the results may be of interest to some of our brother officers, especially as it is not always easy to find readily a simple sensible answer to a simple silly question. Hence this article.

Firstly, the argument is from the particular to the general. This does not mean that the deduction is necessarily unsound, but it suggests that a further examination of the attendant circumstances is desirable before we accept the deduction as proved for universal application. We propose to examine the problem in the following way. First, let us see what ends France is trying to attain by her military action in the Ruhr. Then, assuming that she fails to attain those ends, let us try and find out why she failed, and whether, in any other circumstances, she might have succeeded. Then we may be in a position to form an opinion as to the future value of an army to a modern state.

The question as to what are the aims of the French action in the Ruhr has been asked, if not answered, in Parliament, but, as our study is military rather than political, let us leave Hansard on the shelf and open *Field Service Regulations*, Vol. II, at page 17. There we have a definition of war which fits the French action like a glove.

"War is the ultimate resort of policy whereby a nation, when every peaceful means of settling an international dispute has failed,

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seeks to impose its will on its enemies in defence of its honour, its interests or its existence.

" The armed forces of the Empire are the instruments by which, in the last resort, the national policy is supported and enforced.

" The aim of a nation which has taken up arms is, therefore, to bring such pressure to bear on the enemy people as to induce them to force their government to sue for peace."

Within the meaning of *F.S.R.*, therefore, France is waging war, but before leaving *F.S.R.*, let us turn back to page 14. There we find the following statement :—

" The ultimate military objective in war is the destruction of the enemy's main forces on the battlefield."

But in the case under review the enemy has not got any " main forces " to destroy, and this lack of an objective is the root cause of France's military difficulty. She is trying to use her army, not to bring indirect pressure to bear on the German people through their army, but to bring direct pressure on the people themselves, and that pressure is being countered by passive resistance.

The point is whether such military action could possibly succeed. Could a nation ensure success of military action against civilian resistance if it did something that France, in this case, has not done ? It is reasonable to suppose that force, if used with sufficient ruthlessness, will, in all cases, overcome passive resistance. History abounds in instances of an invader exterminating the entire population of an invaded territory or transplanting them as slaves and colonizing the country with his own nationals. The Israelites did it to the Amalekites and the Assyrians to the Israelites in the Old Testament. The Turks do it to the Armenians in the twentieth century whenever they get the chance. Large portions of the American continent were won in this way. The attacker gained, at least, a cheap supply of labour and the natural resources of the conquered country. These, of course, are extreme cases, and it may be argued that such methods of waging war are only used against savages and that they cannot conceivably be used in modern Europe. It must be admitted, however, that in every case there must be a limiting degree of ruthlessness, far removed from the absolute ruthlessness instanced above, which will overcome the maximum of passive resistance which the invaded nation is prepared to offer.

We are therefore forced to the conclusion that an armed invader will fail against civilian resistance only if the ruthlessness which the invading army is prepared to employ is strictly limited. The invaded state, being itself defenceless, can do nothing to limit the invader's ruthlessness. The limitation must come from the invader himself or from external sources.

There are three factors which, in practice, limit the ruthlessness

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which an invader can employ against a defenceless nation. These are :—

1. Humanitarian considerations.
2. Self interest—the fear of destroying the resources of the invaded territory.
3. Fear of intervention from outside.

One would like to think that modern civilization has so developed the humanitarian instincts of civilized nations that this factor of itself would be sufficient to set the required limit to the ruthlessness of an invader. Alas, this is not so. The old fallacy that " the end justifies the means " is still rampant. It has been detected by their enemies in various creeds : in Imperialism and Sinn Fein, in Capitalism and Communism. It may exist. A state may be, or consider itself, so civilized that its citizens regard their neighbours as revolutionary or reactionary savages, who should be treated accordingly in the cause of progress. Who, bearing in mind the pre-war mentality of the German nation or the post-war mentality of Bolshevist Russia, would rely on civilization to protect his state from the ruthlessness of an invader ?

The second factor—fear of destroying the resources of the invaded country—is hardly likely to deter an invader from being ruthless, but it may rule out certain forms of ruthlessness and thereby, to a certain extent, limit ruthlessness. For example, a nation in need of coal, invading a state rich in coalfields, would not try to bring pressure to bear by the destruction of its mines. It might, however, limit the import of food and allow rations only to the miners and railway employees who continued working. There will usually be plenty of ways of bringing the invaded nation to a humble frame of mind without killing the goose that lays the golden eggs. So the second factor is, in reality, as broken a reed as the first.

It is the third factor—fear of intervention from outside—that is by far the most powerful deterrent of ruthlessness. Neighbours who are not parties to the quarrel are more disinterested and, therefore, more humanitarian than the invader. Or they may be afraid that it will be their turn next to be attacked, and for that reason will not desire that the invader should set up a precedent to be used upon themselves later. They may decide to interfere, to protect their trade interests in the invaded territory. They may be genuine friends of the invaded nation and anxious to help it, or they may hate the invader and jump at the chance of using his " atrocities " as an excuse for biting him in the back while he is busy in front. These are some of the reasons why neighbours may interfere to prevent undue ruthlessness. But there are many cogent reasons which may prevent them from interfering, such as friendliness to the invader, hatred of the invaded, pacifism at home, desire to continue trading

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with both belligerents, fear of ultimate defeat, mistrust of the other neighbours. Who can say which scale will kick the beam in any particular case ?

Intervention may take one or both of two forms, military and economic. Military intervention presupposes that the intervening nations are armed and presents a purely military problem which need not be discussed further. It could not be applied in time to be effective were disarmament general. Economic intervention might be extremely difficult to apply, especially against a state that was more or less self-supporting, and it would be very apt to recoil against the state applying it in the guise of shortage of commodities, loss of trade, unemployment, etc. It is conceivable that the recoil might be so strong as to force the intervening state to raise the blockade. Fear of the attack being turned on them would always make the nearest members of the blockading ring hesitate in applying the economic pressure. Furthermore, it is doubtful whether such a blockade could be rendered effective unless it were supported by force. At least, blockade runners of the blockaded and neutral nations would have to be dealt with somehow.

Nations have in the past disarmed, wholly or partially, trusting to international guarantees of " neutrality." The more recent cases have been far from reassuring. The nation which relies on intervention is, therefore, taking a very grave risk. The intervention may come too late, or it may fail in its object. It may even take the comparatively innocuous form of a series of " notes " which may serve to salve the consciences of the neighbours who send them, but will not help the defenceless nation at all.

So we have come to the conclusion, in spite of the lesson of the Ruhr, that disarmament as a policy of defence is unsound, except if adopted by a state so situated geographically or economically that an aggressor's attack on it would be impossible or fruitless ; that passive resistance can only succeed where the ruthlessness of the attack is limited ; that the strongest factor in limiting the ruthlessness of the attacker is the fear of intervention backed by force, but that to rely on such intervention as a pretext for disarmament would be a policy full of risk ; and that, paradoxical as it may seem, the risk would increase in proportion as disarmament became more general.

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HILSEA ORDNANCE DEPÔT.

By COLONEL J. C. MATHESON.

A SHORT account was given in the March, 1922, number of the *R.E. Journal* of the buildings in Hilsea Ordnance Depôt which presented some points of interest. It has been suggested that a brief general description of the development of this depôt would round off the former article.

This development is best indicated graphically and the attached plan shows the depôt :—

(*a*) As it was before the war.
(*b*) The additions made during the war.
(*c*) The reprovision rendered necessary by the handing over to the Navy of the Gunwharf, Portsmouth.

Before the war the Ordnance establishment at Hilsea was on quite a small scale and contained only the mobilization stores for :—

2 Reserve parks R.A.S.C.
1 General hospital.
2 Clearing hospitals (really C.C.S.).
1 Field ambulance.
2 Ammunition parks (less vehicles).

and some war reserve ammunition.

During the war a number of large sheds were erected, those lettered A.1, A.2, B.1, B.2, C.1, C.2 being for camp stores. The site of these sheds is the old R.E. Fieldwork ground of 30 years ago. The roof-covering of these stores was mostly non-galvanized corrugated iron. In spite of periodical attention to these roofs, they have naturally deteriorated to some extent. In 1922, however, measures were taken which it is hoped, judging from results elsewhere, will prolong their life for many years.

These measures consisted in covering the roofs with felt, well pressed down into the corrugations and made to adhere by a mixture of super-hydrated tar and mastic applied hot, with a top dressing of the same dashed with sand.

Other sheds, marked A, B, C, and D, now used for mobilization equipment, were also erected in war time and were then used for the storage of ammunition.

Another large structure is the vehicle shed, close to the railway

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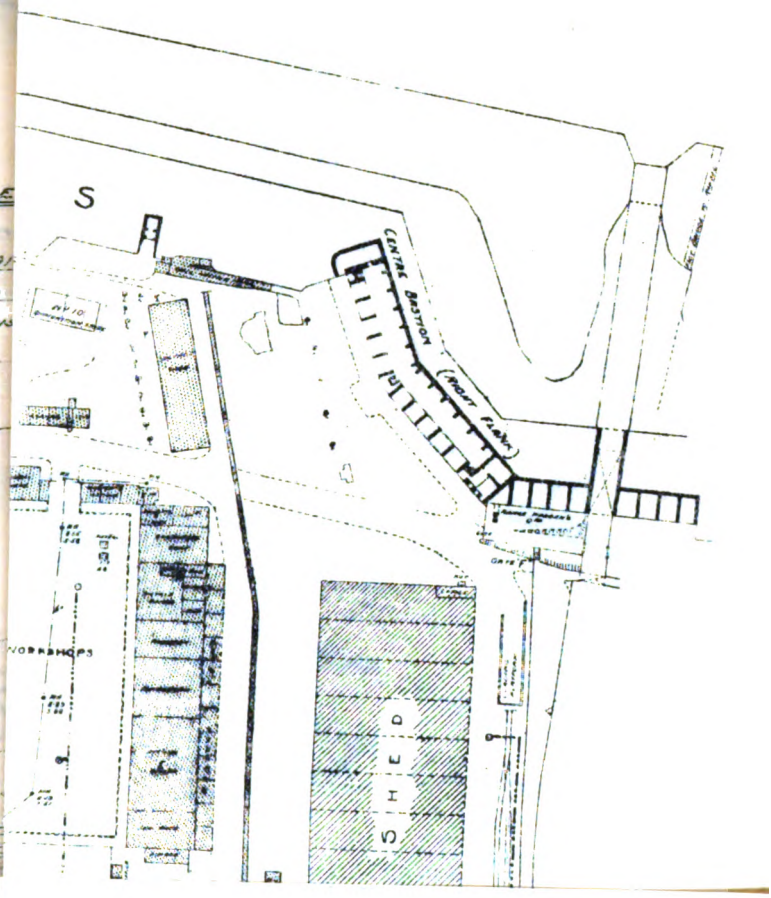

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into Portsmouth. This, during the war, was used to house guns and vehicles on deposit for Woolwich, as they were received from the contractors. Thence they were issued to the various theatres of war.

Before the war there were no railway sidings into the depôt. The war expansion rendered these a necessity and the plan shows their ramifications. It also indicates the fire main. An interesting point about this main is that a portion of this was laid in ashes from the gas works. This caused such serious chemical action that within eighteen months large renewals were necessary, together with the removal of the cinders.

The main works required on the reprovision item have already been mentioned in the March number. There were, however, many minor services :—

Armoury.
Timber shed, coal-yard and wood store.
Locomotive shed.
Railway weigh-bridge.
Movable 15-ton crane.
Loading platform (railway).
Rifle testing range.
Roads.

The original drainage system was a small one and discharged into Langstone Harbour near the depôt. It was not satisfactory and in any case the fall was insufficient to take the whole of the depôt without the use of ejectors. Thus the new drainage scheme was put in, as shown on the *Plan*, discharging into the town sewer. The drainage of the married quarters is separate from the main scheme and discharges into the town sewer, no ejectors being required.

Owing to the ground being so low-lying, a considerable amount of filling has had to be done. The material for this has been obtained from some of the old traverses protecting the rear of the flanks of the bastions of the Hilsea Lines.

It may interest some of its former occupants to know that Hilsea Lodge, the old quarters for the D.O. Hilsea, is now the official residence of the D.A.D.O.S., Portsmouth.

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MODERN DIESEL ENGINE PRACTICE.

By CAPT. J. H. DYER. M.C.. R.E.

GENERAL.

OF recent years great development has taken place in Diesel engine design, due mainly to the increasing adoption of engines of the Diesel type for ship propulsion. Diesel engines can now be constructed of up to 15,000 h.p. per shaft and 2,000 h.p. per cylinder. The main reasons for the high efficiency of Diesel engines are (*a*) the high compression possible, as air only is compressed and not a combustible mixture, as with a gas-engine (in which case the temperature of ignition of the mixture limits the permissible compression, to avoid pre-ignition); (*b*) a leaner mixture may be employed than with a gas-engine, thus reducing the weight of fuel burnt and the loss in the cooling water.

I. OBJECTS IN DESIGN.

1. *Maximum Economy.*—The fuel consumption of modern Diesel engines has been considerably reduced, an average consumption being ·42 lbs. of fuel oil per b.h.p. hour. The adoption of a "dished" piston or a conical shape of combustion chamber has enabled the fuel to be sprayed into a good depth of air, in spite of the small clearance volume. This has resulted in better combustion by making all the air in the clearance space "interested" in the fuel spray and avoiding pockets of dead gases.

2. *Reduced Weight.*—For driving dynamos, high-speed engines running at from 180 to 350 revolutions per minute have been largely adopted. These engines are totally enclosed and have forced lubrication at from 35 to 80 lbs. per sq. in. High speed gives reduced height, weight and capital cost, besides minimizing the size and weight of the dynamo. This engine is not suitable for all purposes, *e.g.*, main engines on ships, as propellor efficiency is a maximum at about 85 revolutions per minute for ordinary cargo vessels, *i.e.*, 12 to 14 knots speed.

3. *Reduced Cost.*—The cost of a Diesel installation is very roughly 25 per cent. more than an equivalent steam plant (including boilers) or gas-engine plant: the cost has been reduced by increased speed, two-stroke cycle, etc.

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4. *Reduced Space.*—By increasing the output per cylinder. Amongst other improvements, the Mean Effective Pressure has been raised to 110 lbs. per sq. in. (from a former average of 95 lbs. per sq. in.). By "supercharging," *i.e.*, a preliminary compression of from 2½ to 8 lbs. per sq. in. of the charge, a great increase in the M.E.P. may be obtained.

II. Modifications of Design.

1. *Solid Injection of Fuel.*—In the older designs air injection is employed: before each power stroke a certain quantity of fuel is delivered by the fuel pump into the fuel valve casing. When the fuel valve opens, oil is blown into the combustion space in a finely divided state by an air blast from the compressor at from 700 to 950 lbs. per sq. in. With the solid injection system, the fuel oil is maintained by the fuel pump at a high pressure (varying between 2,000 and 10,000 lbs. per sq. in. for different designs) in the fuel valve casing and fuel piping. When the fuel valve opens, fuel oil is forced into the combustion space by its own pressure, being atomized by passing through a number of fine holes in the sprayer. The advantage of solid injection is that it eliminates the air compressor, which is always a possible source of trouble and takes up space. As a compressor absorbs from 7 to 10 per cent. of the output of an engine, the mechanical efficiency is improved by the adoption of solid injection, but the I.H.P. thermal efficiency is less, so the fuel consumption on a B.H.P. basis remains about the same. In any case, an air compressor is required to charge the starting air vessels except (*a*) where the engine is driving a direct current generator and storage batteries are available to drive the generator as a motor for starting, (*b*) engines of the Still type, which may be started up on steam on the steam side of the double-acting piston, the steam being generated by lighting up oil burners in the regenerator. It is difficult to obtain good atomization with solid injection, if using very heavy fuel oils of high viscosity. The system has, however been largely adopted for submarines, though the engines are started on air, as an air compressor is required in any case for discharging the ballast tanks.

2. *Two-stroke Cycle.*—In sizes up to about 600 b.h.p. the four-stroke cycle is preferable, as it gives slightly greater economy and is more reliable, as greater experience has been gained in its manufacture. A disadvantage of single-acting two-stroke engines is that the pressure on the main bearings, crossheads and big end bearings, is always in the same direction, and forced lubrication must be adopted; should the lubrication pressure fail, the oil film cannot form in the bearings and a seizure will quickly take place. With the four-stroke cycle the pressure on the bearings alternates, especially on the pumping strokes, and ring or syphon lubrication may be adopted;

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The chief advantage of the two-stroke cycle is that the engine occupies less space for a given output, the power per cylinder being about 1·8 times that of the four-stroke engine of the same size. The adoption of the two-stroke cycle, either single or double acting, is imperative for the largest outputs, as a four-stroke engine of, say, 8,000 b.h.p. would be excessively unwieldy. A scavenge pump is required with two-stroke engines; this does not cause a great increase in the space occupied by large engines, as now turbo-blowers are used. To obtain a high mean effective pressure, supercharging is adopted: the Sulzer design for obtaining efficient scavenging and supercharge by auxiliary scavenge ports is worthy of note. *Fig.* I shows vertical section of cylinder. The air is delivered by the scavenge pump to a scavenge trunk A at a pressure of about 3 lbs. per sq. in. There are two rows of scavenge ports, B and C, the admission of air

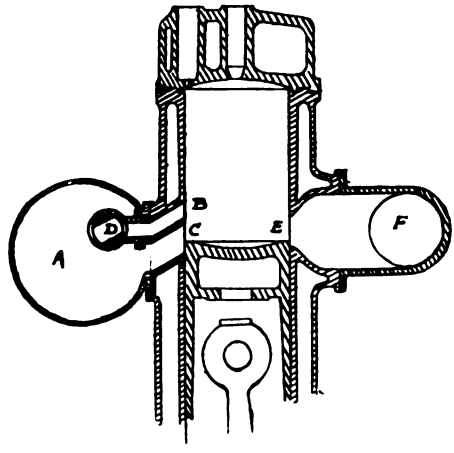

Figure I.

Port Scavenging: Sulzer Engine

to the ports B being controlled by the rotary valve D, driven off the vertical intermediate shaft. As the piston descends, it first uncovers the ports B (which are at that moment cut off from the scavenge trunk by the rotary valve), next, the exhaust ports E are uncovered and the products of combustion escape to the exhaust main F. The lower row of scavenge ports C is now uncovered and the air admitted helps to drive out the burnt gases. As the piston rises the ports are covered in the reverse order: the rotary valve D is now admitting air through the ports B, helping to scavenge the exhaust gases until the exhaust ports E are covered and, after that, raising the pressure in the cylinder to about 3 lbs. per sq. in., giving a supercharge.

3. *Reduction of Compression Pressure.*—With solid injection, the fuel sprays in fastest when the fuel valve first opens, tending to

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cause a rise of pressure at the commencement of the injection period (instead of operating on approximately the constant pressure cycle). In several designs the compression pressure is reduced to about 380 lbs. per sq. in., the pressure rising to 500 lbs. per sq. in. on combustion. As there is less danger of a heavy overpressure due to pre-ignition with this design, the crank shaft may be made lighter, reducing the capital cost. There is only a slight reduction in the thermal efficiency by reducing the compression ratio to give 380 lbs. per sq. in. compression pressure, but the engine is not "cold-starting," as a sufficiently high temperature for ignition of the fuel oil is not attained by compressing air from atmospheric temperature to 380 lbs. per sq. in., when the cylinder walls are cold. The scavenge air must therefore be pre-heated or hot water circulated through the cylinder jacket before starting up.

4. *Double-Acting Engine.*—The advantage of a double-acting engine is saving of space and first cost, especially for very large outputs, as practically double the output can be obtained per cylinder, or, for a given output per cylinder, a much smaller sized cylinder is required; thus the pressure stresses in cylinder liner and cover are reduced, so their thickness may be reduced. This in turn reduces the heat stress, which is the main factor limiting the output per cylinder of Diesel engines. A successful double-acting engine is difficult to design: the lower combustion chamber, through which the piston rod passes, being less efficient than the upper combustion chamber, owing to the following causes (*a*) the cooling effect of the rod on the fuel spray; (*b*) the rod gets cut away by the flame impinging on it; (*c*) difficulty in keeping the piston rod stuffing box tight; (*d*) if two fuel sprays are used, directed eccentrically so that the flame does not impinge on the piston rod. there is a tendency to cause a vortex of unused air, causing incomplete combustion.

5. *Opposed Piston Engine.—Fig.* 11 shows arrangement of pistons and cranks for one design of this type (Junker's type). There are two pistons per cylinder; the top piston is attached by a beam lever to two side-rods coupled to two connecting-rods driving a crank on the crank shaft each side of the cylinder. The lower piston drives the crank shaft by one connecting-rod in the usual way. The pistons move in towards and outwards from the centre of the cylinder at the same time. The engine operates on the two-stroke cycle, the exhaust ports being at the top of the cylinder and scavenge ports at the bottom so that the scavenge air, when admitted near the outer end of the stroke, sweeps up through the cylinder, driving out the exhaust gases through the exhaust ports. The fuel is injected, by a valve arranged horizontally in the liner, when both pistons are at about inner dead centre. The main advantages are: (*a*) As there are no cylinder covers, many difficulties of cooling and jointing are avoided; (*b*) there are no reactionary stresses on the

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framework due to combustion load, as the opposed pistons balance these forces; (*c*) engine should be vibrationless, as the reciprocating masses are balanced. The Fullager opposed piston engine is of somewhat different design: the upper piston of one cylinder has a diagonal connecting rod to the lower piston of the next cylinder and *vice versa*. This engine has been adopted for several land installations; it has several advantages over other opposed piston types, there being only two cranks between each main bearing.

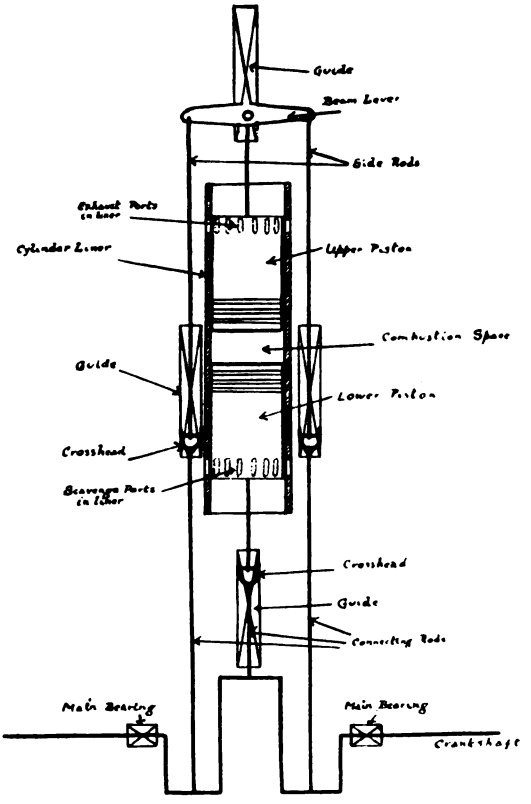

Figure X
Diagrammatic Sketch of Opposed Piston Engine (Junkers Type)

6. *Combined Steam and Internal Combustion Engine.*—This type has been developed by the Still Engine Company and is applicable to gas or oil-engines as well as to an approximation to the Diesel Cycle. With this type the waste heat passing through the cylinder walls during combustion and the heat of the exhaust are used to generate steam which drives the piston on the under side. The feed water is heated in the combustion cylinder jacket to about 340° F. and steam generated in a regenerator, consisting of a water-tube boiler through which the exhaust gases circulate. For starting up on

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steam, and to obtain extra steam for over-loads, auxiliary oil burners may be lit up in the regenerator. This design gives the highest over-all thermal efficiency of any prime mover, but has certain limitations, *e.g.* the high temperature of the piston crown limits the permissible diameter and, therefore, the output per cylinder. The following Table (from Kempe's Engineer's Year Book) may be of interest :—

Type of Engine.	*Thermal Efficiency.*
Marine steam-engine, superheated ...	16 to 17 per cent.
Parsons steam-turbines	15 ,, 20 ,,
Gas-engines	22 ,, 30 ,,
Petrol-engines	23 ,, 27 ,,
Semi-Diesel engines	27 ,, 30 ,,
" Still " gas-engine	31 ,,
" Still " petrol-engine	33 ,,
Diesel engines	30 ,, 36 ,,
" Still " oil-engines (Diesel type) ...	38 ,, 44 ,,

III. Fuel for Diesel Engines.

A wide variety of fuel oils can be successfully used in Diesel engines, the usual fuel being the residue left from crude petroleum when the lighter oils have been distilled off. Some oils having an asphaltum base, such as Mexican fuel oil, are unsuitable for Diesel fuel without special distillation, as the hard ash formed is liable to cause scoring of the cylinder walls. Up to 3 per cent. of sulphur is admissible, as, the exhaust being at a temperature far above that of the dew point of sulphuric acid, corrosion could only take place in the exhaust pipe. Tar oil, obtained from the distillation of coal tar, is successfully used, but requires generally the use of special ignition oil or an increased compression pressure to ensure cold starting and certainty of ignition on light loads, as the ignition temperature of coal tar oil is high. Animal oils (such as fish oil) and vegetable oils can be used, but are generally too expensive. It is interesting to note that in the original design the Diesel engine was intended to run on pulverized coal, but the objections to its use were: (*a*) the highly explosive nature of coal dust ; (*b*) the choking of fine jets ; (*c*) the large amount of ash formed.

IV. Limitations of Diesel Engines.

1. *Largest size.*—The output per cylinder is limited by the heat stresses. The larger the cylinder, the greater the hoop stress in the liner and bending stress in piston crown and cylinder cover. These parts must, therefore, be increased in thickness and this in turn increases the heat stresses, as a greater temperature gradient is required to conduct away sufficient heat through the thick walls to maintain a working temperature in the cylinder.

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2. *Smallest size.*—Below about 35 b.h.p. a hot-bulb engine is more suitable, especially for military purposes, as less skilled attendance is required, first cost is less and fuel consumption is only slightly greater.

V. Advantages of Diesel Engines.

1. Fuel costs per b.h.p. hour are less than for any other type of engine.

2. Great saving in personnel required for attendance, compared to an equivalent steam plant.

3. Efficiency remains nearly constant over a wide range of load as compression remains the same. Overload capacity of 15 to 20 per cent. for 2 hours.

4. No stand-by losses, as engine can be started up at once from cold. About four hours is required to raise steam in a boiler or to light up a producer plant from cold

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TRAINING OF TERRITORIAL DIVISIONAL ENGINEERS.

A lecture by "A CHIEF ENGINEER OF A COMMAND."

WHEN the G.O.C. of the Division asked me to lecture on this subject, my first thought was that none knew better than the Territorial Engineers themselves what facilities they have for training officers and men, and that, with their war experience and the advantage of the new training manuals, the solution of their problems was in their own hands. But I should have been so loth to dissociate myself from their efforts that I am here this afternoon, not in order to push a "nostrum" of my own down your throats or to burden you with personal experiences, but in the hope of examining, so to speak, with you the general principles on which the R.E. work in the field, so that you, perhaps, may be helped in doing your own work, for *you* have to do *for yourselves* the hard thinking that training involves. What is the objective you are aiming at? What are the doctrines you wish to instil? They are laid down for you in *Engineer Training*. Departure from the principles of that manual or the practice of methods not based on those principles is forbidden. This is a hard word not often used. Don't forget it. It is the one point in which enterprise and originality need repression. There is scope enough and to spare for these great qualities, but not in trying to improve on the principles of this little book (*C.I.G.S.*, p. 4).*

May I ask whether every officer and N.C.O. has his own copy of these two books, *Engineer Training* and the *Manual of Field Works*? They have to be mastered—not only read carefully; but as, in many cases, the subject matter is necessarily condensed, they have to be read with a lot of common sense. For example, on page 6 of *E.T.* you will find that the *section* commander's duty is to teach his subsection commanders how to train their subsection in field works, "but it is essential that he should allow them to learn from their own mistakes." Of course, a senior officer in peace training must interfere if he sees a mistake in progress that will endanger life, and pretty quick, too, sometimes. Again, on page 8 of *E.T.* the aim of training is to produce in the men moral attributes of a soldier, fighting spirit, discipline, *esprit de corps*, physical fitness, skill at arms, and skill at his trade. Of course, the latter point includes his trade

* Read extracts from pp. 4 and 5 on C.I.G.S. Staff exercise; Oct., Nov., 1922.

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as a sapper too—the technical R.E. knowledge that he has to add to his qualifications as a carpenter, or whatever his trade in civil life may be.

Again, if you read the amendment of December last to *F.S.R.*, Vol. II, you will find that the erection and maintenance of wire is an infantry task. That doesn't mean that the R.E. are not to be experts at it—digging trenches is infantry work, but I should be sorry for sappers who could not dig. So we want to read the principles intelligently. The exact following of the manuals in details of work is altogether another matter, but when carefully thought out and dimensioned drawings are given us we should always gain by sticking to them. Otherwise, if an officer teaches something else, the learner confuses that with the book example and loses the advantage of seeing the picture reproduced in concrete form. Stick to the book for all the points it covers, and develop originality and resource in any other works that are not in the book. So there we are, with good books for our guides. What is the difficulty in carrying out the training? Of course, in the case of the Territorial Army it is want of time—and sometimes want of materials.

You have to cut your coat according to your cloth. But what are you to select, and what are you to reject? Now, *you* know best what time you can get in the case of each company—even of each section, and how much enthusiasm you can call up so that one hour can be made to serve the work of two. I know you do not expect me to dish you up a syllabus for annual training and save anyone the thinking of his share out for himself. Indeed, I should be gratified if I can give you cause for even greater thought than before. Hard thinking, forethought—that is the work to do if you want to avoid having to change your mind. Avoid change of plan.

But to get on with our training.

First of all, what is the objective? To produce a first-class field company in the field ready for all the tasks that await it. What are these tasks and what is the method of employment of the company? The new regulations and manuals have cleared up a great deal of doubt as to how engineers should be used in the field, and I think that each officer can get a much clearer picture of how the work is to be initiated, authorized and carried out than he could before, or even during, the war. There were great differences of opinion and practice about using the field companies during the war. Now I think I may be able to asist you in stating shortly how the work is to be done in future. Of course, I turn to *E.T.* again. On pages 65–6 you will find that work is ordered by a commander. As a result of the C.R.E.'s reconnaissances and of conferences the G.S.O. of a division in conjunction with the C.R.E. prepares a programme of work and they together take the orders of the G.O.C. as to the

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priority of the works and the agency by which they should be carried out—either by the R.E. or by units other than the R.E. This programme should not include, as I understand it, the ordinary work that troops undertake for their own defence, including obstacles and cover, but would include defence works given to the R.E. as requiring special organization. Brigades are given orders for work by the staff of the division, who also give work orders to the C.R.E., and he issues the necessary orders to his engineer units. Advice may be required to be given by the R.E. to working parties of other arms, for which purpose some R.E. personnel may be present. Before the commander orders work he will satisfy himself by consultation with his C.R.E. that the work is a necessary public service in accordance with the military requirements, and that his resources will enable him to carry it out.

Under battle conditions the procedure is, of course, somewhat modified. We see on page 73 that a proportion of the R.E. are well forward in the order of march, and the rest of the field companies near the head of their division With regard to this the C.I.G.S., p. 34, says, " The bulk of the R.E. should normally march concentrated under the Divisional Commander's orders and not be attached to lower formations." Any portion of a field company detached for a task should rejoin its company on completion. In the attack you will find *E.T.* says (p. 86) that " the engineer assistance required by advanced formations can best be provided by engineers being pushed forward to them from time to time as the situation demands from the engineer reserves in the hands of the C.R.E."

The C.I.G.S. also said, " In an attack the allotment of bodies of R.E. to advance close in rear of the attacking infantry is wasteful of personnel and conducive to loss of control, and it is difficult to conceive of any circumstances in which such employment would be justified. In defence, R.E. should usually be employed on definite technical tasks under the order of the C.R.E.

I should like to quote another exponent of the doctrines laid down in *E.T.*, not quite of the same eminence as the last authority but closer by environment to the point at issue. In the last December number of the *Royal Engineers Journal* there is an interesting lecture by Major Sim, the Brigade Major, S.M.E., on the employment of Divisional Engineers in conjunction with other arms in war. In comparing the two systems that prevailed in the war he speaks of the brigade group school as opposed to the divisional control school and points out that it is this second system, namely, the concentration of the whole engineer problem in the hands of the C.R.E., that has now been officially adopted in our army and on which the doctrine taught in *Engineer Training* is based. Of course, Major Sim is referring to the execution of work, not to the selection and authorization of work which is the function of the G.O.C. assisted by his

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staff and advised by the C.R.E. It is interesting to see from the same lecture that our friends the French have come to the same conclusion as we have. We may now happily conclude that it will be very rare indeed to see field companies either allotted to a brigadier's group command for general use or frittered away among other troops, or wiped out unnecessarily in infantry operations, or employed on works that the other arms can perfectly well do for themselves.

I have not been able to trace these principles of R.E. employment as definitely in any other book as in the *Engineer Training*, and even there they need some searching out and collating. It seems to me a pity that they are not concisely collected in *F.S.R.*, Vol. II—if they are, perhaps someone will correct me. There are many officers who, in war time, are not inclined to accept the training manual of a specific arm as an authority for general guidance. The result, however, is that the C.R.E. is definitely recognized as the G.O.C.'s agent for R.E. work, and he and his officers must be trained to carry out the duties involved, which are reconnaissance, design, *liaison* and intercommunication, consultation and executive work.

Now let us turn to the training of the officer for this. I venture to say that in a R.E. unit more depends on the officers even than in other arms. For one thing, the more highly specialized the machine, the more it is capable of being mishandled. On the other hand, an expert engineer can do amazing work with almost unskilled men. We old hands from India will not forget how Capt. Aylmer (now Lieut.-General Sir Fenton Aylmer, v.c., etc.) thirty years ago, at the back of beyond the frontier, built excellent suspension bridges out of telegraph wire and timber with wild hillmen as his labourers and only an Indian sapper or two to help him. I read the other day of the shifting back of the whole side of a street in Canada, and what interested me most was that the labour was expressly stated to be of the lowest-skilled grade.

Our manual says that in field companies a preponderance of unskilled man-power is required. That is right. But it is very certain that no unskilled officer is required. The civil profession of our R.E. T.A. officers does not teach him all the technical work of the field engineer, but it does teach him to organize work and get it done, and he can learn the rest in training his men, in special exercises for officers of all arms, in reading and in keeping his eyes open all the year round. In my humble opinion no R.E. officer should pass an excavation in the street without looking in to see what is going on—as a matter of fact, he does look in and generally delays the work. When he goes to the seaside he naturally defends the coast line against a boat landing. I do not see how an R.E. T.A. officer can carry on unless the field engineering work is his hobby and his pleasure, and while I am on that point I should like to tell you that when my time is up, the clearest memory of my service

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as C.E. in this Command will be the admiration that I have felt for the Territorial R.E. officers, and the patriotism and keenness that has inspired them in the past. I am sure you and your successors will carry on the torch.

In the first years of their service T.A. R.E. officers go through courses at Chatham and Aldershot—make the most of these, they are a grand opportunity as well as, I hope, a pleasant experience of meeting the regular R.E. at home. They are, I know, a great pleasure to your comrades at Aldershot and Chatham.

Is there any difficulty about complying with the instructions for these courses?

Now how about the officer's normal training? Without the need of troops or materials, and in his own time, he can practise reconnaissance, design, the detail of working parties and demands for material and transport—and, to make a success of this work *with his men*, he should practise it beforehand before he tries his hand on them.

Schemes of all kinds can be tackled and discussed, examples will occur to all of you such as—

(*a*) Engineer works required for the defence of a brigade or division front with detailed working-party Tables.
(*b*) The preparations for erection of a long length of wire entanglement or revetting of a trench by night, including supply and carriage of materials.
(*c*) Water supply for a brigade.
(*d*) Reconnaissance and construction scheme for a "medium" or "light" bridge.
(*e*) Assault crossing of a river.
(*f*) Preparation for demolition of various types of bridge.
(*g*) Area demolition scheme for a force retiring.
(*h*) Engineer reconnaissance of an area, etc.

One useful practice is estimating task work for infantry working parties. I have never known this sufficiently practised in peace, and have seen sorry errors in the field as the result. Sometimes the task given is far too much, sometimes far too little—one has to take a normal task and apply all sorts of factors for weather, the spirit of the troops, the physique of the unit—in order to get a fair task. Note your own men's work and compare it with the Table in the *Manual of Field Works*.

Before I leave the officer, may I, as in all cases, commend to him the words of *Engineer Training* on the functions of a leader, and stress the last lines of the instruction there given on p. 7: "Lastly, the ability to command includes the ability to execute an order through subordinate commanders without interference with their personal responsibility."

I wish the words were not quite so long, but the doctrine is all

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right. It is more than a training note ; it is a great truth. I should only like to cap it by the words of a very gallant and distinguished general, who told a conference of officers that he wished to give them something to take away with them. He said, " The corollary of the delegation of responsibility is effective supervision." We can carry both these precepts into practice in our civil life, and so train ourselves for war, although I do not quite recommend them for household use.

One point more, train your junior officers so that they may have the tact and humanity to be successful as *liaison* officers and in dealing with commanders and their staffs. It is better to risk hurting their feelings when young than to find they are not *persona grata* later on. When we are in uniform we do not mind having our feelings hurt.

Now, as to the training of the N.C.O.'s and men. Hold tight to the principle of giving the sub-section commander his own job to do. You know better than I can tell you how to deal with the individual training of the men. Lectures, discussion, reduced scale work, model-making and the study of models all help you indoors. I should be glad to hear to what extent companies have models.

Now as to the collective training of the unit ; this is the puzzle. How are we to produce a field company capable of facing its varied tasks in war without having time to practise in peace the works in which you wish to make the unit efficient ?

At first sight it appears impossible, but, of course, it is not so at all. Records of the territorial companies in the war show how valuable the companies were as soon as they got out. The difficulty is not special to R.E. work. The infantry cannot really practise producing an effect on a living enemy with rifle and machine-gun fire, the artillery cannot practise a creeping barrage and see how closely the infantry can follow it up. One cannot reproduce in peace the sensation of being warmly shelled. I think you will agree that the *technical* difficulties of military engineering are really more easily to be reproduced and tackled in peace than are the difficulties that the other fighting arms are more specially trained to encounter. And as regards the practice in peace of certain particular works, remember that, as so many of you know, a field company in war spends a great deal of its time in doing things that it has never heard of before, things that certainly are not in the pictures in the books. What you want to produce is a body of divisional engineers in which the whole or any part, down to a sub-section, can work as a team under its commander. The R.E. leader who can look ahead, foresee his needs, organize his labour, materials and transport, will never find his sappers fail him—never. Even the restricted opportunities of a ten-days' camp will give plenty of practice in this team organization. If, after the day's work is done, every

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officer and N.C.O. feels that sound but not dull instruction has been given to every man all the time—then all is well. Not a man off the work who can possibly be got on to it. No standing about waiting for this or that, no crowd of men too thick upon the ground or doing each other's jobs, no precious camp-time wasted in doing something that might just as well be done indoors in winter-time, no change of plan that wastes work and makes men feel that they would not have worked quite so hard if they had known *that* was coming, no miscalculation of the time the job will take, no smash caused because something that was thought "just good enough" has, as usual, turned out "just *not* good enough," no accident because a safety precaution was overlooked. If he can fill that bill every day, even a successful civil engineer will find that a Territorial R.E. camp has stretched him a bit.

But he will have gained the confidence of his men. Then the unit or the section will work as a team *whatever* the task. Remember that, with the training that their trades give them and this confidence of which I speak, territorial sappers under a trained officer will do most of their jobs as quickly as a regular company, and perhaps some even more quickly, because the T.A. men of the building and engineering trades are in more regular practice at those trades. Remember that time is generally the essence of the contract.

Let us turn, therefore, to the R.E. jobs in which a man's civil trade does not help him directly, and ask how the principles of engineer training apply to these. Which are the most important of these, which of these can be done at other times than in camp? How far can a progressive system of training be adopted for successive camps? But you must think these out in detail for yourselves. One principle seems to me to need decision: what standard of work should you attempt?

Let us consider the *Manual of Field Works for All Arms*, not forgetting that the special engineer's work begins where this leaves off. If I were a territorial infantry officer with so much else to teach my men, I should rather stand in awe of that book. I should almost be reduced to hoping for the best.

But for the sapper it is a really friendly book, it tells you a great deal of your job and tells it very well. The *Manual* is divided into five parts:—

FIELD FORTIFICATION.
BRIDGING.
ACCOMMODATION.
COMMUNICATIONS.
DEMOLITIONS.

In the case of "Field Fortifications" and these other headings, should those who are responsible for R.E. T.A. training try to exercise and perfect their men in these simple works, or aim at

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combining with them more elaborate works as shown in the various parts of *M.M.E.*? It may be held that, as the greater includes the less, men exercised in the more elaborate work will learn enough about the simpler work by models, pictures or examples carried out by others. On the other hand, the danger is of trying to run before you can walk, and the more elaborate an engineering work is the more time it takes from other training and the more materials it requires. This is the point that I would rather hear T.A. officers discuss than press my opinions on them. May I hope that when I sit down the C.R.E. and other officers will tell us their views? Only one revised volume of the *M.M.E.* has appeared yet, namely, *Bridging*, so one would naturally turn to that for the latest practice.

I am afraid that materials will form the ruling factor and that, unless the locality of the camp provides special facilities, or special stores, such as heavy girder bridges, are available, the simpler training will be the rule. But in bridging and structural work I should always feel happier myself if I were practising something that the infantry cannot be expected to try. One might be obliged to let successive companies or sections take the job on, and even then only complete it in part. Of course, if one can find a job that wants doing and that gives good instruction, that may be the ideal opportunity; for instance, one field company last year felled a tall chimney for a corporation—and with success.

As regards the *Manual of Field Works* (*All Arms*), every R.E. unit ought to feel sure of itself in the whole work, but I think especially so in certain points. These are revetting, trestle and floating bridges, the use of heavy spars, blocks and tackles and anchorages, watermanship and demolitions. In preparing a programme of training, read carefully p. 111 of *Engineer Training*, which discriminates between the duties of divisional and corps engineers, and follow the principles for the normal distribution of work, bearing in mind that we are, at present, training for mobile warfare.

Now, as I have attempted to deal with general principles, I hope I have led you to the point when your own knowledge of circumstances is the best guide, and I should like to ask for your own conclusions as to how far territorial engineers can find the time to make good in the various more elaborate technical works described in the several parts of *Military Engineering* as contrasted with the *Manual of Field Works*. I am only sorry that the conclusion of my time in this Command prevents my visiting you again in camp next summer, and that this may, perhaps, be the last occasion when I can hope to see a gathering of the officers of the Divisional Engineers.

DISCUSSION.

In the discussion that followed company commanders were asked to speak first and to deal, among other points, with the question

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whether nowadays the company training in camp should be in the simplest subjects, or whether more advanced work should be attempted.

The Officer commanding one Field Company said: One must face the fact that at present men join for the pay and the outing in camp. Patriotism may be a greater incentive when the effects of the war wear off. The first thing is to get the military training of the recruits done by the permanent staff. You cannot get sufficient regularity of attendance and uniformity of instruction from the T.A. N.C.O.'s. Let the recruits do their technical training with the platoons; none of the men are so advanced as to make this unsuitable. Get the range practices done before camp. There may be 25 hours for collective training apart from week-ends and officers' training. Company commanders should know the C.R.E.'s skeleton programme for the ten days in camp a month before the camp begins, and they can fill it in.

C.R.E. to arrange lectures for wet days.

The important subjects for camp are:—

1. *Mobility.*—To pack and unpack, know all the tools that are carried, and why. To get quickly to work.
2. *Field Fortification.*
3. *Bridging.*—Stick to the divisional engineer's tasks. Specialize in light bridging rather than girder bridges.
4. *Water Supply.*—Distinctly a field company job, wanting more practice by officers and N.C.O.'s than by the men.
5. *Demolitions.*—Officers and N.C.O.'s are those who need the training. In his war experience he had noticed that the British Field Company demolitions were generally futile, while the German demolitions were efficient. He believed that the Germans rightly made the preparation for demolition in case of retreat a corps job. Field companies have not the time. British field companies were sometimes not allowed to prepare demolitions lest it should have a demoralizing effect on the infantry.

Omit mining and tunnelling from field company camp work at present.

The ten days' programme for camp might be (including the training in mobility):—

Three days, defences (including camouflage, not too much digging). Each company to see the other company's work.

Two days, pontooning and use of spars.

Three days, each company to specialize in one type of bridge—trestle, pontoon, barrel-pier and flying bridges (to change the type in the following camps). Bridging to include approaches to those and marking communications.

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One day, rapid wiring and obstacles.
Leaving one day unallotted.

The Officer commanding the second Field Company said that it is difficult to get recruits of the best class. Get the men together to make the company drill-hall a club and get the company established. The T.A. has to count on a period of intensive training before going into the theatre of war.

Keep to the simplest forms of technical training, with illustrations of the work, full knowledge of what the equipment is and what it is for. Great difficulty in organizing lectures. The same lot do not turn up twice running and you have to begin again. Models very useful.

The Officer commanding the third Field Company said he agreed with the two company commanders who had spoken before him. Every sapper should have a *Manual of Field Works*, if only for the illustrations. The best results will be from training in the simplest subjects. Make the camp programme progressive over four years. Officers to take the N.C.O.'s separately from the men. Officers depend on self-education. Lectures are difficult. He started a course of lectures for the men; ten days, 1½ hours, once a week—two men turned up. In camp each subaltern should have his section, horse, vehicles and equipment, and be responsible for his men's clothing and equipment.

T.A. officers would be glad to hear results of Chatham researches dealing with advances in military engineering. He expressed great appreciation of Chatham courses.

The Adjutant: Try and work N.C.O.'s towards the *Manual of Field Works* standard. Men to keep to field works and simplest forms of bridging, *e.g.*, assault bridges. Officers to get on to the military engineering volumes.

Recruits certainly should be in the hands of the S.-Serjt. instructors; T.A. N.C.O.'s cannot provide the necessary regularity.

Keep a "backward squad" going in camp to catch those who would otherwise try to be spectators.

The C R.E.: Agrees with company commanders; certainly keep recruit squads under permanent staff. The "backward squad" in camp is a good suggestion. Agrees with proposal for a four-years' training programme.

The companies must have an attractive headquarters, a good "canteen institute" for the men, and a good mess for the serjeants.

The salvation of the T.A. lies in getting the new lad. Make the whole thing a club; it can get along all right without drinking. Stick to the elementary technical training. Make it simple and interesting.

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ADMINISTRATION OF ENGINEER SERVICES IN PEACE-TIME.

By COL. G. WALKER, C.B.E., D.S.O.

"WHAT a dull subject," I think I can hear someone say. "What do I care about Engineer Services in Peace-time?" whispers another. Dull in some respects, I grant you, but still, every one has to think about dull things sometimes, not necessarily for his own amusement, but for the good of other people.

If anyone gets as far as this, I hope he will go on and finish reading this article, as I can assure him that he will not be bored with dull technicalities or statistics, as I propose to approach the subject in rather an unofficial way. I want rather to point out a train of thought, than to force attention to the Regulations for Engineer Services.

The young Engineer officer is taught certain technicalities relating to building and estimating for which he is sometimes at a loss to know the reason. He imagines they have nothing to do with war and war is, in his mind, the ideal employment. He is wrong; the knowledge he is acquiring will be most valuable in war, and his application of it in peace will help him immeasurably in war.

Why are there such things as Engineer Services during Peace? The answer is that they are carried out in order to provide for the comfort, health and consequent efficiency of the Army during peace. An army is a collection of human beings (a fact too often forgotten), who require just the same amenities in their lives, as do their brothers and first cousins in civil life. Like the civilian, the soldier requires a comfortable roof to sleep under, he wants to wash and bathe, he enjoys well-cooked food, he marries and requires a comfortable home in which to keep his family, he desires to worship his Maker with his fellows and hence requires a church, he reads the papers, plays cards, is fond of games and exercise, as other young men, and requires facilities to enable him to do all these things. A paternal Government realizes all this, and as far as in them lies, considering their straitened finances, they provide for these things through the agency of the Engineer Services; an agency which is administered by the officers of the Royal Engineers. Somebody will say, "we all know that without anyone writing about it." Some do, no doubt, and as it is no use trying to teach old dogs new tricks, may I particularly draw the attention of junior officers

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to these brief remarks that follow? How is the young officer personally affected? I think as follows. His first connection with the administration of R.E. Services will be probably as an Assistant Division Officer somewhere, possibly he may have a whole division thrown at his head. His first duty is to keep quite cool about it, survey the situation, make the acquaintance of his subordinates (foremen of works, etc.) size them up and look at his show from the outside for a bit to see how it is going on.

Speaking generally, his business is to see that the money allotted to him for definite works is being properly and economically expended, that the money he has in his own hands for allotment to work is allotted so that the greatest benefit shall accrue to the troops, that he shall have such a thorough personal grasp of the situation, the condition of his buildings and the requirements of his troops, that he may be able at once to say what is the most beneficial way to spend any money that may come his way in the future. In all this he must be in constant touch with the officers commanding the troops in his Division and must know their wants. He must advise them as to how the regulations affect their aspirations and prove to them that he is only out to help them in every way, consistent with the rules of the game. To do this properly our young officer must have cheerful manners and he must know the technicalities of his job thoroughly, so that he can advise judiciously.

Now a few hints as to methods :—

(*a*) A thorough knowledge of your fellows is not attainable unless you constantly rub shoulders with them, learn ***their*** point of view; to achieve this it is useful to feed with them and play games with them. Therefore, our Assistant D.O. must try and do all these things. He must not be a recluse, who is only seen in plain clothes in his office. He must go amongst the troops and be in uniform; there is nothing derogatory in the King's uniform, and, moreover, it is not uncomfortable; but also it must be clean.

(*b*) In making Inspections do not be perfunctory. Do it well, talk to the men you see and ask them about things. If you go into a barrack room, ask if the light is good. The solitary occupant will probably say "yes sir," whatever is the state of the case, his idea being that this expression is non-committal and will save him trouble in the future. He has visions of irate N.C.O.'s who will want to know "what the devil odds it makes to him whether the light is good or bad." If you look up you will possibly see no mantles on the incandescent burners, or that the electric light bulbs have been removed, because it is the summer season and the evenings are long. The point is, see for yourself, don't believe all the smooth things you hear from

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people, who want to move you on, so that they may do something else, which is more amusing. Another thing about this light is, that the summer-time is the time to get it right, so that there shall be no discomfort when the days are short and dark. Lighting should occasionally be inspected at night. A "D.O." can do a lot in helping to make barrack rooms cheerful if he tries. The colouring in many barrack rooms is offensive to the eye. Many have always been coloured the same way since the flood, almost. When redecoration is on the *tapis*, consult the people who see the rooms every day, and get their views, then help them within your money. They will babble of green fields and "hedge-sparrow green" and what not; listen and do your best. It will give trouble; it may even alter the details in certain ancient records labelled "painting" and your understrappers may think you are a fool. Never mind, you know better. Remember you are in command of your little show, that you have made up your mind you are going to command it. You also are determined that people who worry you are going to drop in for more trouble than they thought. That's the only way to live. The Engineer officer must be the mainspring of his show and not just let it jog along on its own.

(*c*) I have dealt with barrack rooms at some length, but there are other things also. The married quarters, for instance, where some of the men and women of the next generation are growing up. If they are to be well brought up, they must see nice things and be happy. Our Asst. D.O. can help in that, but he must go and see; don't wait for reports. The troops must report their difficulties, but, if our R.E. officer's subordinates are allowed to wait for reports, before doing anything, that officer's show will be a bad one. Another item, there are churches to be looked after. The troops *have* to go to church and hence their church must be decent in appearance and comfortably warmed and lighted. The chaplain will not be slow in telling of his troubles, but, quite apart from the fact that it is good for him to go to church like the men, it is the R.E. officer's duty to be in church sometimes, both morning and evening, to see what he can do to help things along. It is better that he should abstain from breakfasting in "plus fours" on an occasional Sunday morning and do his duty both to God and to his fellows. Similarly, canteens, recreation establishments, shooting galleries, serjeants' messes, officers' messes and hospitals must be thoroughly investigated. Hospitals in particular require constant care and attention, particularly

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in those stations where they are of old construction. Modern standards of hospital design and finish should be studied, and a good way of doing so is to get some one to conduct you over some first-class modern hospital and to note the points where care and attention in the treatment of walls, floors, sanitary annexes, etc., will remove possibilities of dirt or germs being harboured. It is seldom possible to provide all the amenities asked for by medical officers, but much can be done by intelligent co-operation with them to improve the conditions for the care of the sick.

(*d*) Inspections are of various sorts, the casual ones alluded to above, and the more formal, Quarterly ones, when every defect is supposed to be written down for future action. While on this subject, the young R.E. officer must not, when he notices something during a casual inspection, be taken in by the remark, "that's down on the 'Quarterly,' sir." It may be quite true, but the point I want to make is that it is not enough to have defects written down on a piece of paper or in a book. The R.E. officer exists to get things put right and it is up to him to raise Cain if they are not put right and struck off the book in reasonable time. The great point to realize is that the young officer's job is to *command* and supervise his subordinates and see that they do their work. Hence, he must avoid embroiling himself in details that are the work of other people, though he must know broadly how the detail should be done, to see that it is done properly by his subordinates.

The foregoing remarks may seem rather appalling to a person who is going in to the business for the first time. There is really no reason that it should be so. The great thing is to take an interest in the people for whose comfort you are responsible, then it all follows quite easily. There is no slavery in a well-organized show—when everyone has his allotted task and is allowed to do it *without constant interference*. Command and supervision don't mean interference: some people forget that no two men do the same thing quite the same way; the thing to do is to look after the principles upon which methods are based.

If our R.E. officer has knowledge, tact and an interest in the people he is working for, he will soon find that his little command seems really all his own, and then his work will have no semblance of drudgery. It may take time to get into it at first, mayhap long hours occasionally, but that will pass. It should never be forgotten that the time given to any job is not necessarily a measure of the efficiency with which it is done. Some men stick in an office from early morn to dewy eve and never do anything much worth while.

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Over-anxiety about things is another pitfall. It is waste of energy and brain tissue. "Care killed a cat" is a very true saying. Let a man do his best according to his conscience and, if his conscience passes his work, he need fear no other critic, but you must listen to your conscience !

Lord Macaulay says that, in his day, some men in the House of Commons disclaimed essays and hence failed to convince, while some literary people wrote speeches and also failed—I fear this article comes under the latter category. I hope it may not fail in its object, namely to show that the administration of R.E. Services by Royal Engineer officers is important, and that it is the spirit in which work is undertaken that really matters and makes the difference between success and failure.

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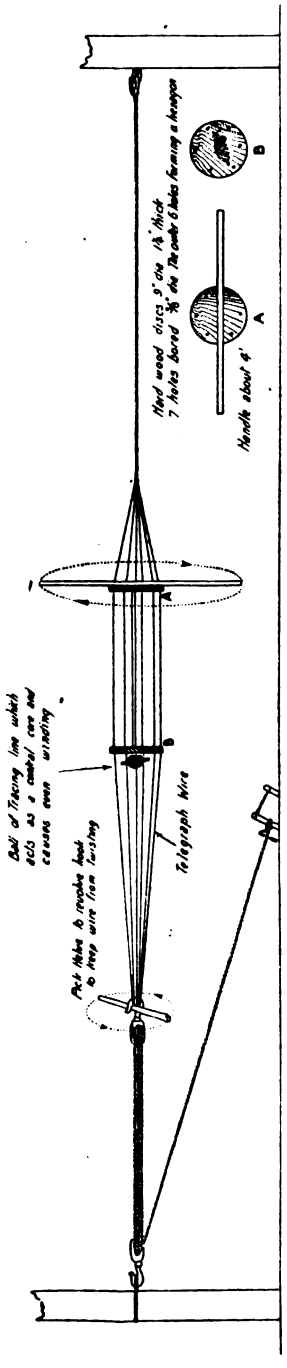
PROFESSIONAL NOTES.

METHOD OF MAKING UP A WIRE ROPE OUT OF TELEGRAPH WIRE.


B
A
Handle about 9"
Ball of Tracing line which acts as a centre core and carries even winding
Put thro' to make last 6 turns wire from twisting
Telegraph wire

THE following method of laying up telegraph wire to form a wire rope has been found to be an improvement on that shown in *Plate* XXVI, M.E., Vol. III (a), 1913.

Six strands of telegraph wire are threaded through the outer holes, and a tracing line through the centre hole, of the two hardwood discs A and B. The ends of these seven lines are made fast to a post. The other ends of the wires, after being strained evenly, are attached to the revolving hook of a block and tackle which is connected to a post at a suitable distance away. The wires are twisted together by revolving the disc A which is gradually moved along the wires according to the angle of lay required.

The centre hemp core is kept taut by being fastened in a ball to the disc B, which is moved along as required.

When completed, the wire rope is "seized" two or three feet from the end and the spare part cut off, as it is found that the rope does not commence to lay evenly until this distance is reached.

With six strands of Z.23 telegraph wire and a core of tracing line an evenly laid 1½-in. wire rope can be made by two men.

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THE INSTITUTION OF MECHANICAL ENGINEERS.

MEMORANDUM REGARDING ADMISSION TO THE INSTITUTION OF OFFICERS ENGAGED IN OR HAVING PASSED THROUGH E. AND M. COURSE.

THE Institution of Mechanical Engineers has very recently revised the conditions of entry to the classes of Associate Members and Graduates, and has created a new class of Students. Under the new arrangement it is intended that the Student class should be open to engineering students or apprentices at the outset of their training, whereas the Graduate class should be confined to those who have actually "graduated" (*i.e.* passed the Associate Membership Examination or a recognized exempting Examination) and have also had some workshop experience, although they may at the time be undergoing instruction either in works or in Engineering Colleges. The position of the Graduates has thus been greatly improved; this class was formerly practically equivelant to the new class of Students, but is now intermediate between the latter and that of Associate Members.

Under these new regulations, the Council of the Institution have very generously agreed that the E. and M. Course should be looked upon as the equivalent of an apprenticeship in Works, and that the normal course passed by officers at Woolwich, Chatham and/or Cambridge University should be considered as the equivalent of the non-technical portion of the Associate Membership Examination.

The Institution is, therefore, prepared to consider application as under from officers who are undergoing the course or who have passed through it.

As Graduates.—Those under 30, provided they pass two subjects in Section C—Technical Knowledge in the Associate Membership Examination. On passing this portion of the examination, their names would appear in the printed Pass List as having passed the examination, and, after election, they would be able to obtain a Certificate of Graduateship.

As Associate Members.—Officers of 27 years and over who have passed an E. and M. Course and the Associate Membership Examination under similar conditions as those just described, and in addition can satisfy the Council that they have had sufficient practical experience in mechanical engineering, and are at the time of their application engaged in mechanical engineering work.

Officers who hold the Cambridge B.A. Honours Degree in Engineering Science, or the B.A. Ordinary Degree, provided they have passed the Special Examination in Engineering Science and the Special Examination in either Chemistry or Physics, are exempt from the whole of the Associate Membership Examination.

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The following letter has been addressed to the Secretary, Institution of Mechanical Engineers, by the Secretary, Army Council :—

43/Misc./4317 A.G.7.

2nd May, 1923.

SIR,

I am commanded by the Army Council to inform you that it has been brought to their notice that the Council of your Institution has very kindly consented to extend the privileges already granted to Officers of the Corps of Royal Engineers in the matter of admission to your Institution and have sanctioned the Electrical and Mechanical Course, which some officers now undergo, being looked upon as the equivalent of an apprenticeship in Works.

The Army Council desire to express to your Council their appreciation of the action taken and to assure them that the privilege will go far to accentuate the close relationship between civil and military engineers, which the Army Council have so much at heart.

I am, Sir,

Your obedient servant,

(Signed) H. J. CREEDY.

The Secretary,
Institution of Mechanical Engineers,
Storey's Gate,
St. James's Park, S.W.1.

REPORT ON THE HOT-WATER APPARATUS ERECTED AT 28TH DIVISIONAL BATHS, CHANAK KALE, ON CAPT. K. B. S. CRAWFORD, R.E.'s PRINCIPLE FOR SUPPLYING HOT-SPRAY BATHS FOR THE TROOPS.

By COLONEL P. T. DENIS DE VITRE, D.S.O., R.E.

1. *General Description.*—The apparatus consists of :—

(*a*) A closed brick furnace and flue, into which is built a coil of iron piping made of water-pipe fittings. The latter takes the place of a boiler.

(*b*) A hot-water cistern just above the brickwork of the furnace connected by flow and return pipes with the coil in the furnace.

The secondary flow is taken off from the top, and cold water admitted at the bottom of the cistern.

There is no secondary return.

The apparatus was made of odd materials. The cylinder is apparently a Turkish oil-drum. The brick furnace was built by a miner. The opening for admission of fuel is closed by a piece of biscuit tin. The apparatus is rough and cheap ; nothing elaborate about it.

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2. *Working Conditions.*—Eight sprays are used. These are of the French spray pattern (Ch. Blanc); in fact, the heating apparatus is connected to the secondary flow of a French spray set, which is at present out of order, thus allowing of the admission of cold water to temper the hot water coming from the new cistern. The furnace is constructed for wood and charcoal; it is too large to burn coal economically. This, however, could be arranged with a narrower coil and firebox if desired.

3. *Particular Points in the Construction.*—

(*a*) The coil is square in plan, 16 in. each way outside measurement, these being the inside dimensions of the furnace, and consists of six complete turns of inch piping.

(*b*) The primary flow pipe comes from the top coil and is taken up through the bottom of the cistern to within one inch of the top. It is not essential that it should go up through the bottom of the cistern, provided the hot water from the coil is delivered near the top of the cistern; but a certain amount of radiation is thereby saved.

(*c*) The primary return also passes through the bottom of the cistern and is taken up 20 in. above the bottom, this height being two-thirds of the height of the cistern; here, again, the height is the essential point; this pipe is connected to the lowest point of the coil.

(*d*) The cold water is brought into the cistern as low as possible, and rises to the point of delivery, so as to prevent any circulation in the cold-water pipe.

(*e*) An expansion pipe is fitted.

Capt. Crawford's contention is that the admission of the cold-water supply to the bottom of the cylinder instead of into the boiler, and the extension of the return pipe up to two-thirds of the height of the cylinder, results in a continuous flow of hot water to the baths.

4. *Test.*—By order of the Divisional Commander this apparatus was tested under the supervision of an R.E. officer and an R.A.M.C. officer.

The fuel was weighed before consumption and the number of men bathed was accurately recorded.

Water at 110° F. at the furthest rose, 31-ft. run from the R.W. cistern, can be obtained within fifteen minutes after lighting the fire.

Between the hours of 0830 and 1730, less an interval of one hour, for dinner, 787 men were bathed with a consumption of fuel of 286 lbs. of wood, *i.e.*, 0·363 lbs. of wood per man bathed—or total cost of 4s. 7d. at local price for wood.

At the beginning, and again just after the dinner-hour, water was too hot, so a little cold water was admitted [*vide* 2 above]

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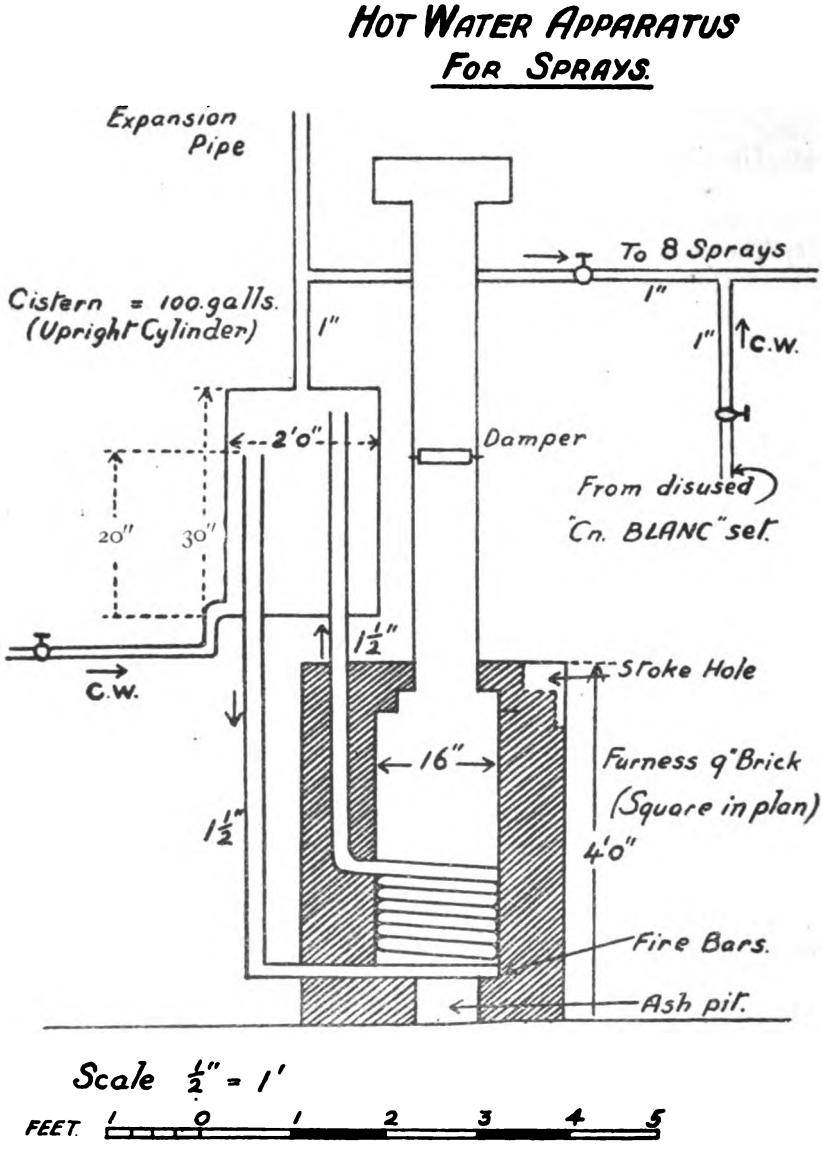
for an hour or more, when it was cut off again, the continuous supply of water sufficing to keep it from getting too hot.

This test, I think, thoroughly justifies Captain Crawford's ocntention in para. 3. During the test I, on three different



occasions, felt the cylinder and found the bottom two-thirds cool and the top one-third too hot to hold the hand hard against it.

The consumption of fuel records of this apparatus during a normal day's work, when men were not being constantly bathed, but when the

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boiler had comparative intervals of rest and reduction of fuel consumption, the fuel consumption during 8½ working hours, less one hour for dinner, was 110 lbs. of wood, costing 1s. 9d., or 80 lbs. of charcoal, costing 3s. 6d. (before the present emergency this would have cost 1s. 10d.).

Normally, with eight sprays 100 men can be bathed per hour.

5. *General Remarks.*—This apparatus was designed on the lines of the experimental apparatus now fitted in No. 1 Cookhouse (men's baths), Buller Barracks, Aldershot, which was tested in July and August, 1921. The results of the test are filed in the Division Office, R.E., Stanhope Lines, Aldershot.

A further point is there illustrated, *viz.* (*f*) Secondary return delivering into the cistern at a height above the bottom equal to two-thirds the height of the cistern, *i.e.*, at the same height as the primary return.

The points mentioned in (*b*), (*c*), (*d*) of para. 3, and (*f*) above, are all considered essential to economy in fuel consumption.

The French spray boiler uses upwards of 1 cwt. of English coal (lump) in the working day, but it will not burn slack. Local value of lump and slack combined as supplied to troops is 2s. 9d. per cwt.

The French spray sets are too fragile for continuous work; they require constant repairs.

The sprays are too small—get choked up with grit, and men unscrew them to get more water.

(EDITOR'S NOTE.—The apparatus here described appears to be a modification of the "Nissen" down-draft incinerator, with water heating coil, which was extensively used in France.)

SLUMP TESTS FOR CONSISTENCY OF CONCRETE MIXTURES.

CONSIDERABLE importance is now attached to the question of the amount of water which should be used in concrete-mixing. It has been clearly established that excess water in a mix causes loss of strength, and that, provided the concrete be properly mixed and consolidated, a fairly dry mix will yield a concrete of greater strength than the mushy mix frequently employed. On the other hand, in certain classes of work, notably reinforced concrete, where tamping is difficult, a wetter mix must be employed to enable the concrete to flow readily in the moulds. But here again, the mix should be no wetter than required for practical reasons, in order to avoid unnecessary loss of strength. Workmen employed in mixing will always have a tendency to add too much water, in order to lessen

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the work of mixing and placing. It is, therefore, very desirable to have some means of specifying the consistency of a mix, so that the proportion of water used may be as small as is compatible with the practical conditions of the work.

The amount of water used for each gauging is not a true criterion of the plasticity of the mix, for this will be also affected by the porosity and varying moisture content of the aggregate and the grading of the sand.

The object of slump tests is to provide standards which will enable the engineer to determine the amount of water required in a mix for any degree of workability, and to check the consistency as work progresses.

The method consists of filling the freshly-mixed concrete into a bottomless mould, which is lifted as soon as it has been filled. The slump or subsidence of the mass is then measured, and the amount of subsidence is taken as a measure of consistency. No standard apparatus exists in England, but a suitable mould consists of a truncated cone of 12-in. vertical height, and having diameters at the top and base of 4 in. and 8 in. respectively. Handles should be provided on the outside of the mould to facilitate removal.

To carry out an experiment, the mould is placed on a sheet of iron or other impermeable material, and the mix to be tested is filled in and consolidated by lightly rodding with a pointed iron bar of about $\frac{5}{8}$-in. diameter. Some little practice with the apparatus is required before consistent results can be obtained; it is, therefore, advisable that the first determination of consistency and subsequent checks should be carried out by the same person.

Fresh tests should be carried out for each consignment of materials received, and for varying atmospheric conditions, as the amount of water required for a given consistency will alter with the nature and water content of the aggregates.

The results of some experiments carried out at the School of Military Engineering, Chatham, are given in the accompanying graphs. Curves A and B are for a 1 : 2 : 4 mix, using Thames ballast passing a $\frac{3}{4}$-in. sieve and retained on a $\frac{1}{4}$-in. as a coarse aggregate, and Thames ballast passing a $\frac{1}{4}$-in. sieve as a fine aggregate. Curve A was obtained by taking the aggregates from a heap exposed to the weather, while curve B was for dry aggregates. Curve C represents the conditions for a 1 : 2 : 4 mix, in which a different sand was used, and curve D is for a 1 : 3 : 6 mix.

A common characteristic is the high rate of increase of the slump after a slump of about 2 in. has occurred. This is due to the complete collapse of the cone after the mould has been lifted. The occurrence of this collapse does not indicate any definite physical change in the mix, since it is obvious that the consistency at which it occurs will vary with the slope of the sides of the cone; nor does it correspond

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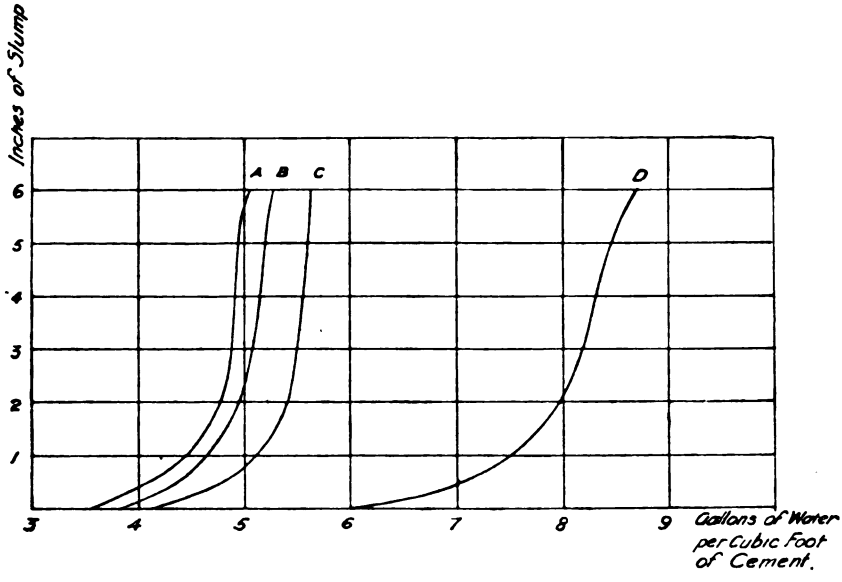
to a sudden loss of strength on the part of the concrete. It does, however, indicate a consistency at which the concrete will readily flow into intricate moulds without much tamping, *e.g.*, in reinforced concrete work.

At a slump of 6 in. the consistency is so fluid that the fine portions of the mix tend to flow away from the coarse ; such a mixture would, therefore, fail to give concrete of uniform consistency.



The consistencies recommended for different classes of work are indicated by the following slumps :—

For reinforced concrete—2 to 3 in. (depending on the intricacy of the reinforcement and possibility of tamping).
For mass work—about 1 in.
For unreinforced roads—0 to ½ in.

The value of the slump test as a method of specifying consistency lies in the elimination of the uncertain factors of the water content and porosity of the aggregates. The limitation of the method is the difficulty of obtaining consistent results after a slump of 2 in., *i.e.*, about the point of collapse of the cone. The slump test should, therefore, not be interpreted too strictly ; in other words, a batch of concrete should not be rejected simply because the slump is a little higher than was intended. The principal value of the test as a check is to prevent the habitual use of such an excess of water as will materially lower the strength of the concrete.

J.C.P.T.

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APULIAN AQUEDUCT.

IT is, perhaps, worthy of note that, on the completion of the Apulian Aqueduct in Southern Italy, a water distribution service, comparable to many of the large works carried out on the other side of the Atlantic, will have rewarded the genius of Italian engineers after 16 years spent in construction. An account of this gigantic undertaking appears in the *Engineering News Record*, of March 1st.

Water is taken from Caposele Springs on the western side of the Appennines and brought by means of tunnels totalling nearly 50 miles in length to the Eastern side, whence it is distributed to a population of some 3,000,000 people scattered over an area of 8,100 square miles.

The main trunk running to Taranto is about 150 miles long and there are 840 miles of main and subsidiary branches. The maximum *capacity* of the aqueduct is 137,000,000 gallons per day and the *allowances* of water per head per day vary from 24 gallons in the case of the bigger towns to 10·6 gallons in the case of small communities dependent on pumped supplies.

The *Storage Capacity* is at present low and at the best only allows for a 72-hour supply. As the country is subject to violent earthquakes, which may cause, in the main trunk, damage requiring much more than 72 hours to repair, it is probable that means will be found to remedy this defect in the system.

Aqueduct Headworks.—Springs were intercepted by means of about a dozen tapping galleries which empty into a common collecting channel which conveys the water through a feeder canal to the intake of the aqueduct. These tapping galleries have a uniform rectangular section of 2 ft. 7½ in. × 3 ft. 11 in. The bottom is unlined natural rock. Side walls are of concrete blocks whose vertical faces are 6 in. apart. Roofs consist of concrete slabs resting on the sidewalls. (See *Fig.* I.)

All the collecting and intaking system is under cover.

Main Trunk.—Tunnels of circular or horseshoe section are considered good against earthquake shocks. They are all lined with brick or concrete. Three main tunnels are each about 10 miles long and their sectional area varies from 75 sq. ft. to 52 sq. ft.

Most of the remainder of the main trunk is composed of a cut and cover canal, the top of the conduit being ballasted with not less than 6½ ft. of selected material, in order to maintain a low water temperature.

Ravines, etc., are crossed :—

(i) By means of aqueduct bridges, a feature of which is that the conduit is made structurally independent of the bridge. It is insulated by means of air spaces in order to keep the water cool. (See *Fig.* II.)

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(ii) By means of siphons, employed where bridges would have cost much more. Siphons all consist of twin pipes of steel or reinforced concrete. A siphon over 70 miles long has been designed for the Lecce branch.

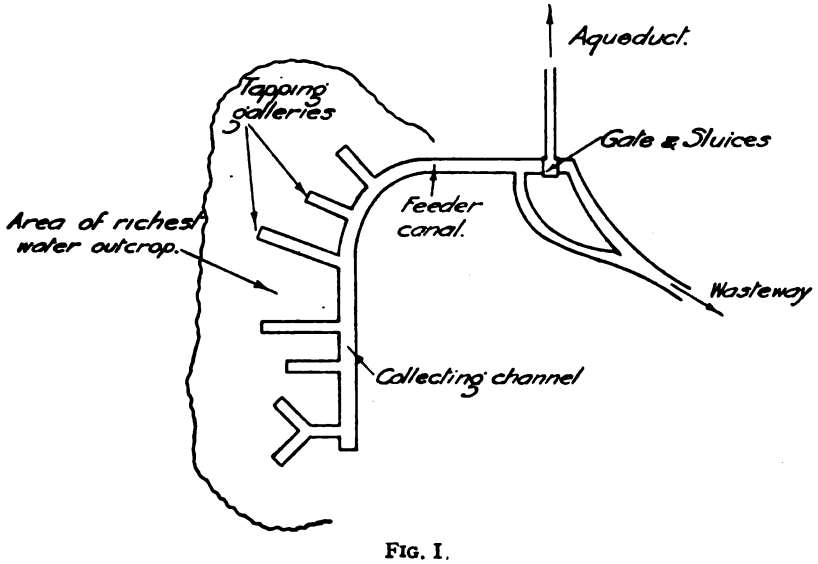

FIG. I.

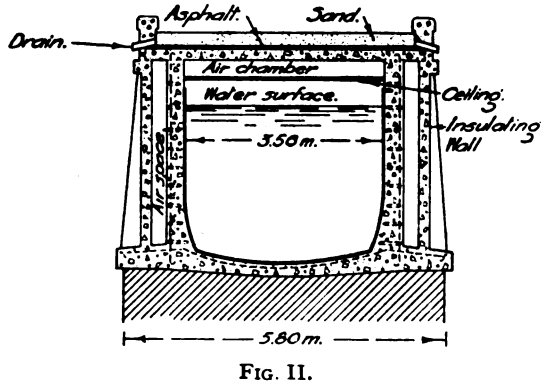

FIG. II.

Main Branches.—These consist largely of reinforced concrete pipes varying from 6 in. to 32 in. diameter, and made mostly by the centrifugal method.* Concrete is fed into a rotating steel cylinder containing the reinforcement which consists of helical wires crossing each other. The centrifugal force generated by the rotation of the cylinder distributes the concrete and produces a pipe shell of uniform thickness. An interior coating of $\frac{1}{8}$ in. of asphalt is applied in the

* A notice of this method, under the title of *Hume Reinforced Concrete Pipes*, appeared in the *R.E. Journal* of July, 1921.

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same manner. The pipes are left in the cylinder for 24 hours, then kept wet for 48 hours, and finally buried in gravel for 15 to 20 days. On removal from the gravel they are stored in a shady place for a period of 1 to 2 months. The standard length manufactured is 3 metres.

"Eternit" pipes (asbestos and cement) have also been largely used with satisfactory results.

Cost.—The original estimate for the scheme was about £5,500,000.

A.G.B.B.

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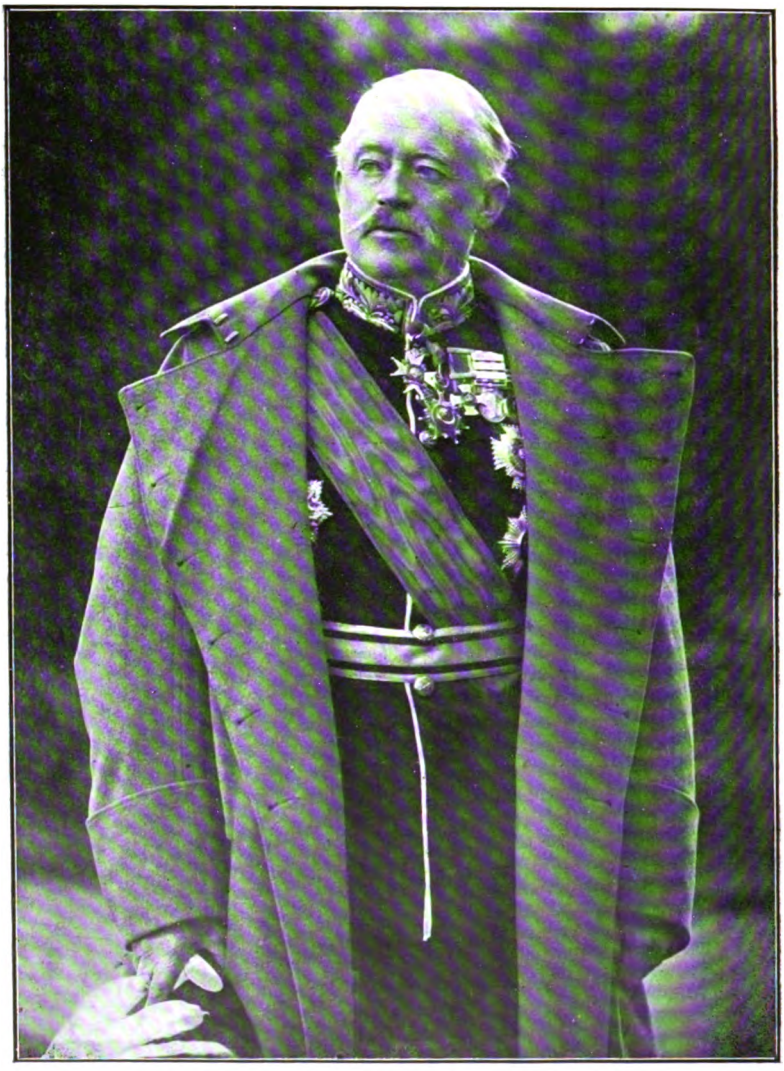

Lieut.-General Sir Henry Hamilton Settle, K.C.B., D.S.O.,
Colonel Commandant, R.E.

Photo by Elliott & Fry, Ltd

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MEMOIRS.

LIEUTENANT-GENERAL SIR HENRY HAMILTON SETTLE, K.C.B., D.S.O., Colonel-Commandant R.E.

LIEUT.-GENERAL Sir Henry Hamilton Settle, K.C.B., D.S.O., R.E., whose death at the age of 76 is announced elsewhere, will be chiefly remembered for his services during the South African War. From that test he came out with credit. He had retired some three years before the European War.

The second son of Captain H. T. Settle, of Southover, Lewes, he was born on January 27th 1847. He was sent to Cheltenham and gained his commission as lieutenant in the Royal Engineers in 1867 He first saw active service with the Sudan Expedition of 1884–85, when he took part in the operations on the Nile as D.A.A. and Q.M.G. at Gemai and on the lines of communication, being mentioned in dispatches and promoted Brevet Major. From 1886 to 1892, Major Settle filled the post of Surveyor-General and Q.M.G., Egyptian Army. In the meanwhile he was engaged as Senior Staff Officer in the operations at Suakim, being present at the actions of Gamaizah and Toski, and at the capture of Tokar. For his services he received two mentions and was promoted Brevet Lieutenant-Colonel and awarded the D.S.O. In 1892 he was appointed Inspector-General of Egyptian Police, and three years later came home to take up the appointment of Assistant-Inspector-General of Fortifications at the War Office. In 1898 he was created C.B.

For a few months in 1899 he commanded the Royal Engineers at Malta, whence he was called in October to take part in the South African War. Before Paardeberg, Roberts had already ordered three small columns to be formed by Settle, the commander at Orange River Station, to check the course of the rebellion in Cape Colony. Settle himself took the right column to cut off Liebenberg. One of the other two columns, however, was repulsed, and Kitchener was sent to take command of the operations with strong reinforcements. His plan was the same as Settle's, who joined him in Prieska on March 21st, and was given the task of bringing to order the rebels left in the

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outlying districts south of the Orange River. In this he was successful, and when he reached Upington, on April 3rd, there was nothing to do but to arrange for the policing of the disaffected districts. Settle then returned to Cape Town to resume his work as Inspector-General of Lines of Communication.

In September, 1900, Settle, in co-operation with Methuen, was ordered from Vryburg to relieve Schweizer Reneke. He entered the town unopposed, and then, in October, he was ordered to the Free State. In the Boer invasion of Cape Colony and the great hunt for De Wet, from December, 1900, to March, 1901, Settle played his part. Kitchener adopted his recommendation that martial law should be at once proclaimed in Cape Colony, and ordered him to take command on the line of communications between De Aar and Naauwpoort, and to organize all available troops to prevent the passage of this railway. At the end of December, Settle, in command of four columns, pursued Hertzog, who was forced back to the north-west. In Kitchener's plan of the following February against Hertzog and De Wet, Settle, who became for the purpose of the operations, Lyttelton's Chief of Staff, was entrusted with the duty of giving all orders for moves to the fifteen columns engaged. The plan was so far successful that the fear of an immediate rising in Cape Colony was removed, and in March, Settle resumed the direction of operations against Kritzinger and his comrades. In April he was transferred to the Western part of the Colony to organize resistance to some rebel bands under Maritz and Conroy. In May he left South Africa on temporary leave of absence, and the huge territory he had controlled was split into four. At the end of October, Settle returned, and, after an inquiry into the administration of martial law and a short term of command at De Aar, succeeded in December to the administrative command of Cape Colony in succession to Major-General Wynne. For his services in the war he was twice mentioned in dispatches, promoted to the rank of Major-General for distinguished service in the field, and advanced to K.C.B.

In 1904 General Settle returned to England, and in 1905 was given the command of the Coast Defences at Portsmouth, where he remained until 1908, when he was promoted to the rank of Lieutenant-General. He retired from the Army in 1911.

General Settle married, in 1875, Edith, only daughter of John Rigg, of Wrotham Hall Park, Kent, by whom he had a daughter and a son. The latter was killed in action in 1918.

The funeral was at Bath on Thursday, April 26th.

(*Extract from "The Times" of Tuesday, 24th April,* 1923.)

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Lieut.-Colonel Hugh Drummond Pearson, D.S.O., R.E.

Photo by Swaine.

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LIEUT.-COLONEL HUGH DRUMMOND PEARSON, D.S.O., R.E.

HUGH PEARSON died of blackwater fever at Um Dafog, Darfur Province, Sudan, on the 28th December, 1922, on the eve of the completion of his work as British representative on the Anglo-French Commission for the delimitation of the frontier between the Anglo-Egyptian Sudan and French Territory (Wadai). The protocol was to have been signed by him and the French Commissioner on 1st January. This work, which had been in progress for some fourteen months, was the crowning achievement of eighteen years' service as Director of Survey in the Sudan, broken only by special service during the Great War. On its completion Pearson was to have left the service of the Sudan Government and he was looking forward to the enjoyment of a well-earned rest after many years of arduous work.

He was the second son of the late David Ritchie Pearson, M.D., and Jean Rae, and was born at Kensington on the 17th February, 1873. He passed direct into Woolwich from St. Paul's School and obtained his commission in the Corps in 1892. Two years later he went to India. He saw service in the Tirah Expedition of 1897–8 and with the China Field Force in 1900–2; he was present at the relief of Pekin and was mentioned in dispatches. In 1902–3 he was British representative on the Anglo-Liberian Boundary Commission. Returning to West Africa in November, 1903, he was in charge of the Colonial Survey Section operating in Sierra Leone, when he surveyed the sources of the Niger at Tembicundo.

In January, 1905, he succeeded Colonel Talbot as Director of Survey to the Sudan Government. Survey work in the Sudan was then, a short time only after the re-occupation of the country, in its infancy, and offered a wide field for Pearson's untiring energy. One of his first tasks was to push on the cadastral survey of the cultivable lands watered by the Nile, a necessary preliminary to the all-important question of settlement of native land-ownership. In addition to dealing with the land bordering the river north of Khartoum, in Khartoum, Berber, Dongola, and Halfa provinces, there was the problem of the tract known as Gezira, lying in the triangle, south of Omdurman, formed by the two branches of the Nile, White and Blue, and approximately the 14th parallel, the scene of the great schemes now being executed for bringing this area under cotton cultivation. The country is flat and featureless, and Pearson decided on a system of squares, with sides of a minute of arc, marked on the ground by beacons, from which points the detailed survey was filled in. Some 5,000,000 acres have been surveyed in this way at a cost of about a shilling an acre.

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At the same time the triangulation begun by his predecessor was steadily continued, extending over the western province of Kordofan, south to the Lado Enclave and the Bahr-el-Ghazal province, and on the east to the Red Sea littoral. In 1911, in Kordofan, Pearson himself, in less than three months, fixed upward of 100 points over an area of 20,000 square miles. At various times he fixed personally a large number of telegraphic and chronometric longitudes at places on the upper reaches of the Blue and White Niles and at other remote points of the country. Although the topographical survey of the country is not completed, maps of the whole of the Sudan on the 1/1,000,000, 1/250,000 and other scales are now available. Town surveys of the principal cities and many special surveys in connection with concessions, the demarcation of basins, etc., have also been carried out.

In 1910 Pearson presided over the Commission appointed to take over the Lado Enclave from Belgium on behalf of the British and Sudan Governments. In 1912 he accompanied the expedition in the Beir country, taking this opportunity to obtain valuable information regarding the Pibor River system. In 1913 he received the Murchison Grant of the Royal Geographical Society " for his surveys and other geographical work in the Sudan."

During the war Pearson was employed on a variety of special services. In 1916 he proceeded in charge of a mission sent to Lake Tsana in Abyssinia to obtain information and data required in connection with a proposed dam at the neck of the lake. During the same year and in 1917 he was at Jeddah as *liaison* officer with the Arab forces. Later in 1917 he represented the Sudan Government at the coronation of the Empress of Abyssinia, and was charged with conveying the G.C.M.G. to the Regent at Adis Ababa. Subsequently he joined the Egyptian Expeditionary Force, was for short periods Military Governor at Jaffa and of Jerusalem, and at the time of the final overthrow of the Turks in Palestine was C.R.E. of the Desert Mounted Corps. For his services during the war he was awarded the brevet of Lieutenant-Colonel and the D.S.O. In addition to war medals, he received at various dates the Orders of the Osmanlieh and of the Nile, the Star of Ethiopia, and the Nahda, the latter from King Hussein.

Pearson's last work, the delimitation of the Darfur-Wadai boundary, some two thousand miles of frontier, has already been referred to. Actuated by his high sense of duty, he continued this work throughout the rainy season in Darfur and this, no doubt, undermined his strong constitution. He had married, in 1919, Blanche, daughter of the late Colonel R. E. Grigg ; she was on her way from England to join him in the Sudan when the news of his death reached her.

The above is a record of Hugh Pearson's services to his country.

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To describe what he was to his many friends is not so easy. There remains the impression of a most lovable personality. Most vividly, perhaps, one remembers his almost childlike simplicity, his complete unselfishness, and his intense vitality. Whatever he did, at work or at play, he did with his might, and, whatever doing, and with whomever dealing, he missed no detail in his constant endeavour to make things go happily.

Sir Lee Stack, Sirdar and Governor-General of the Sudan, writes of him: "By Colonel Pearson's death the Sudan has lost a keen, energetic and capable officer, an able administrator and a delightful personality. Whatever the post he held—and they were many and varied—his conduct was marked by the same enthusiasm, the same efficiency and boundless energy, the same cheerfulness and sympathy with others in the face of difficulties, which made him the ideal type of officer for a country like the Sudan. He won the regard and esteem of everyone with whom he came in contact, and his tragic death, at a time when he was on the point of retiring from Government service to enjoy a well-earned rest, has been universally mourned by all races alike."

Another friend in Khartoum says: "He was just the type of man fitted to help in building up a country like this; always cheery and happy himself, he strove to make other people cheery also. Nor was his interest in people limited to those of his own race, but he was also courteous and sympathetic to all races that worked under him, and, as we know, won their confidence and great regard. He gave his support to everything that went to form a good, healthy public opinion in the community in which he lived."

The following appeared in the *Spectator* from a civilian friend, now in Baghdad, who was Pearson's contemporary for many years in the service of the Sudan Government: "The death from black-water fever of Colonel Hugh Drummond Pearson, D.S.O., R.E., which took place in South-Western Darfur, many miles from road or rail or navigable water, at a moment when the Wadai-Darfur Commission, over which he presided, had delimitated some two thousand miles of frontier and had all but completed its labours, will arouse public sympathy and regret for a gallant and distinguished officer serving the Empire in its outposts. . . . The area of the Sudan approximates in size to that of India, and its inhabitants had just emerged from a disastrous and savage tyranny. Yet in a few short years the political and technical services, hand in hand, under the wise and tactful guidance of Sir Reginald Wingate, had conferred the benefits of civilization on much of that vast area. Pearson was Director of Surveys for nearly twenty years, and a glance at the map will show that he had, perhaps, the most strenuous task of all, the mapping of desert, forest, marsh, and a maze of varying and uncertain waterways, in addition to the more detailed work connected with

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land settlement and the like. He was a great hunter and a fine athlete. . . . At headquarters he was the life and soul of Khartoum society, the friend of all and the hero of many. . . . England and the Royal Corps may well be proud of Hugh Pearson and the type he represented."

To those who had the privilege of his friendship Hugh Pearson's life remains a lasting inspiration; to the younger generation of Sappers the record of his career should be an incentive to follow his example of self-sacrificing devotion to duty and strenuous service.

E.V.T.

(*A very appreciative memoir was published in the Geographical Journal for March*, 1923, *over the initials R.W.*—EDITOR).

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BOOKS.

THE D.U. TECHNICAL SERIES.

LINE Charts for Engineers, by W. N. Rose, B.Sc. Eng. (Lond.), published by Chapman & Hall, Ltd., 11, Henrietta Street, London, W.C.2, price 6s., is a useful little book for those who are interested in the application of "nomograms" or "alignment charts" to the solution of technical problems.

The author has explained in a very clear manner how to adapt formulæ for representation by charts, and how to construct suitable charts.

He commences with simple addition and subtraction charts carrying natural scales and in easy stages works up to charts involving logarithmic plotting.

Practical examples are given, such as a chart for the solution of Unwin's Formula for welded steel tubes,

$$P = \frac{147\,2600\, l^{2\cdot1}}{l^{3}\, d^{1\cdot16}}.$$

Unless a large number of calculations has to be made from the same formula with varying functions, the time spent on the compilation of a chart will not be repaid, nor can extreme accuracy be obtained from any chart, but under certain conditions "nomograms" are very valuable as time-savers.

Great stress is laid in the book upon the choice of suitable scales of notation; otherwise there will result a chart difficult to read.

As an example of a choice of suitable scales and for the benefit of those designing reinforced-concrete beams, three charts have been prepared for the solution of the formula

$$r = \frac{A_t}{bd}.$$

Fig. 1 is graduated in a natural scale.

Fig. 2 is graduated in a natural scale derived from the square roots of the functions

$$\sqrt{r} = \frac{\sqrt{A_t}}{\sqrt{bd}}.$$

Fig. 3 is plotted from logarithmetic values and is based on the fact that

$$\log r = \log A_t - \log bd.$$

Of the three charts probably *Fig.* 3 is most easily read.

The values used when graduating the charts are the natural values, and not their square roots or logarithmetic values; otherwise the charts would be of little convenience.

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The value of $b \times d$ has been plotted as one of the variable functions, as the multiplication of these two values is usually a very simple operation.

It may be argued that the results obtained from the use of alignment charts could more easily be found from tabulated Tables of values, with less liability of error, but the compilation of such Tables would usually be a much longer process, and in most engineering problems the degree of accuracy obtained from a well-designed chart is sufficient for all practical purposes.

D.K.E.

FIG. I.

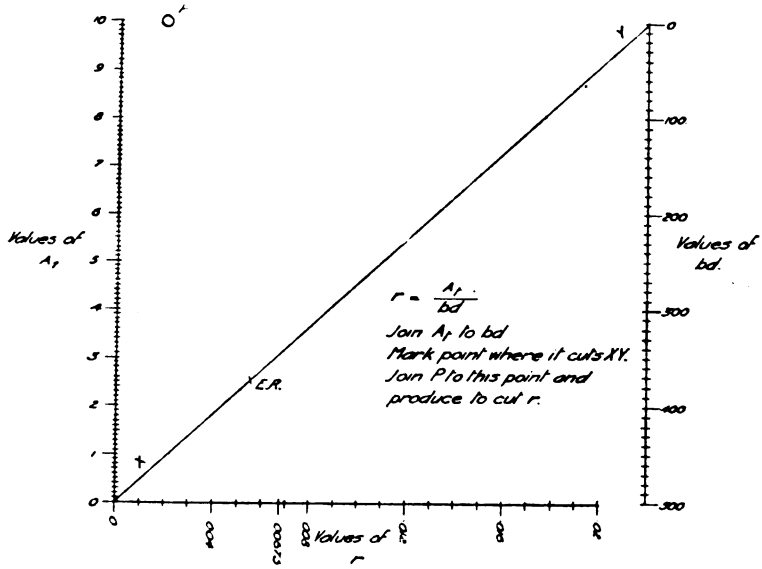
Values of A_s
Values of bd.
Values of r
$r = \frac{A_s}{bd}$
Join A_s to bd
Mark point where it cuts XY.
Join P to this point and produce to cut r.
E.R.

FIG. II.

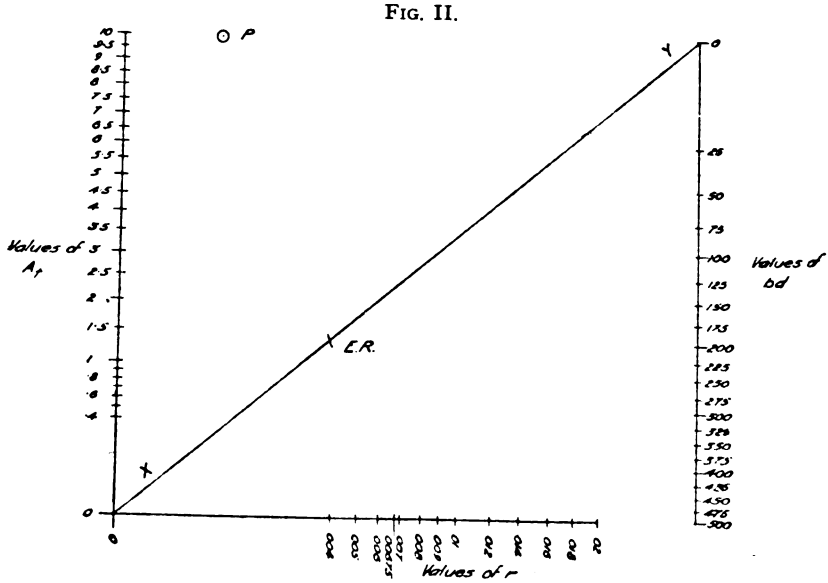

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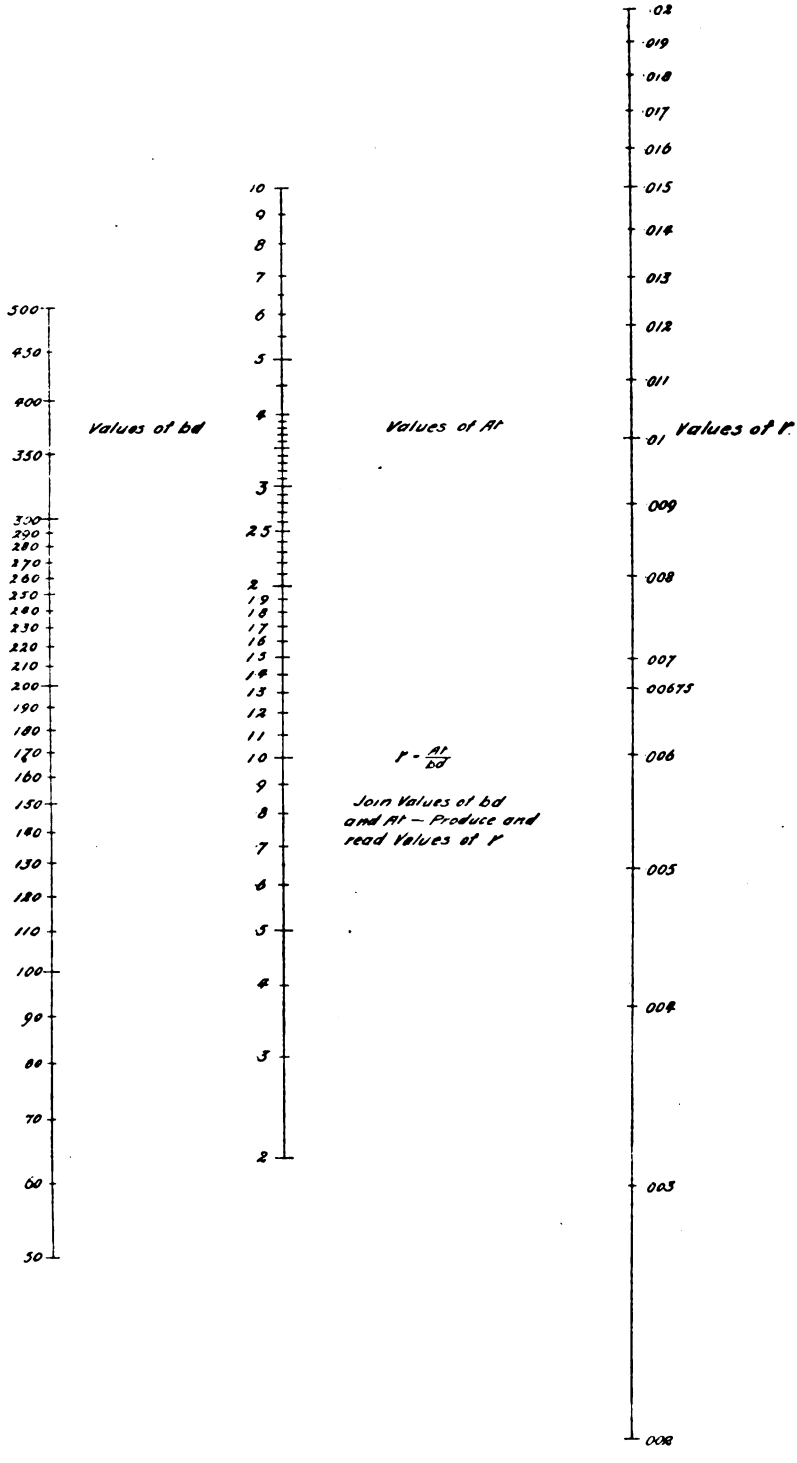
FIG. III.



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SIWA—THE OASIS OF JUPITER AMMON.

By C. DALRYMPLE BELGRAVE. With an Introduction by General Sir REGINALD WINGATE. (John Lane. 15s. net.).

SIWA, the original home of the Senussi, has a special interest for the Corps, from the fact that during the war Colonel the Hon. M. G. Talbot negotiated there the triangular treaties between Italy, Great Britain and the present head of the Senussi Confraternity, a little-known but most important achievement.

Mr. Belgrave spent two years in Siwa in 1920-21 in command of a section of the Frontier Districts Administrative Camel Corps, and for some time as District Officer of the oasis; and he devoted his spare time to discovering as much as possible about the history of the place and the manners and customs of the community. As a result, he has produced a most valuable and entertaining book, illustrated by his own brush and camera.

The story of Siwa begins in the 13th century B.C. It is the father of all the oases, in that Herodotus gave it the name "Oasis," and from it all other fertile spots surrounded by desert have derived their generic title. Nevertheless, it eventually fell into British hands, taken by a 200-mile dash of armoured cars from the coast: it almost seems an act of vandalism, or at any rate disrespect, to such antiquity. The natives, we are told, now have a wholesome dread of "trombiles," as they call motors.

The author has secured a sixteen-page preface from General Sir Reginald Wingate, in which he, with his unique knowledge of and authority on things Egyptian, reviews the connection between the Egyptian Government and Siwa in recent days. It is a most important piece of historical work, and should be read, it may be said without derogation to Mr. Belgrave, even by those who have time only to skim the rest of the book.

J.E.E.

A CHAPTER OF MISFORTUNES.

By Major-General W. D. BIRD, C.B., C.M.G., D.S.O.

(Forster Groom & Co. 8s. 6d.).

Reviewed by Major H. N. KERMACK, R.E.

THIS book deals in detail with the battles of Ctesiphon and the Dujailah Redoubt in the Mesopotamia Campaign, with a summary also of the events leading up to each battle. The author did not personally take part in the campaign, but has compiled the account from reports, war diaries and personal narratives, including that of a Turkish Staff Officer. The two maps are based on the Ordnance Maps, but are on rather a small scale. They are suitably placed in the book and open clear of the pages. There is a good index.

General Bird has written an unbiassed, though very critical, account of these operations. He has been very fair in "endeavouring to interpret the feelings and mental workings" of the men with whom

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the decisions rested, and only gives his opinion after stating the arguments on all sides. It is a book from which many lessons, both strategical and tactical, can be drawn, and is a valuable addition to the military history of the Great War.

Two of the principal points regarding this campaign, over which controversy has raged, are discussed in full:—

(i) The further advance for the purpose of gaining Baghdad after the capture of Kut-al-Amarah by General Townshend. The author's views of the lessons to be gained can perhaps best be summarized by the following extracts: "It has been said that the military professional mind is of necessity an unimaginative mind. But it can hardly be suggested that the sometimes fatal power of imagination was not in the ascendant as regards operations in Mesopotamia, for almost everyone was so much absorbed in considering the advantages of gaining Baghdad that the dangers and difficulties that must be encountered were somewhat too readily discounted"; and again: "The moral, therefore, is that the probability of obtaining success cannot fail to be jeopardized when unity of direction and control is absent."

(ii) The decision to stop at Kut after Ctesiphon. Here General Bird comes to the conclusion that, tactically, Kut was unsuitable for withstanding a siege and that, strategically also, the balance of argument was against stopping.

The book brings out well how the predominant factors in both strategy and tactics were those of time and transport. Can the relieving force delay until certain reinforcements or certain transport can arrive from Basrah? If we delay, can the Turk bring up more reinforcements in the time than we can? For how many troops can we manage to bring up supplies from Basrah? How many troops can the Turk keep supplied east of Kut? Have we sufficient land transport to operate at a distance from the river? These were the type of problems which the Army and Corps Commanders had always before them.

As regards the battles—

(i) No very clear impression can be obtained from the description of the battle of Ctesiphon, possibly owing to the war diaries relating to it having been lost at Kut. Probably, however, the impression of confusion which is given corresponds to the actual state of affairs, many changes and interchanges of position having been made by the various columns. Diagrams showing the actual situation at different times would, however, help considerably. It may be noted that the Sappers and Miners appear to have been employed more as infantry than as sappers.

(ii) The action at the battles of Shaikh Saad, Wadi and Hannan is only indicated by means of small diagrams.

(iii) The battle of the Dujailah Redoubt is described in full, from the approach march to the retirement. The author criticizes frankly the orders issued by General Aylmer for the attack

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and also comments adversely on the action of certain of the Column Commanders in carrying them out. Diagrams of the situation at different times would again assist very materially in understanding the position.

Although intensely interesting, the battle of the Dujailah Redoubt is depressing reading, for it is one of the most striking examples of what might have been.

The Campaign and the book end in the same tone :—

" Kut-al-Amarah surrendered on the 29th April and the attempts which had been made by the British to reach it had then involved some 23,500 casualties in battle, or a larger number of men than that with which Aylmer had first advanced in January, 1916."

A SCIENCE OF INFANTRY TACTICS SIMPLIFIED.

By CAPT. B. H. LIDDELL HART. (William Clowes & Sons, Ltd. Price 5s. 6d.)

THIS book was first published in 1921 and has now been revised. It is an elaboration of the lectures delivered by the author in the R.E. Lecture Theatre, which were published in the *Royal Engineers Journals*, of April and May, 1921.

SUSPENSION BRIDGES.

By Dr. D. B. STEINMAN. (Chapman & Hall, Ltd. 1922. Price, 20s.)

THIS volume is divided into four Chapters. Chapter I (68 pages) deals in a concise and clear manner with the stresses occurring in both stiffened and also unstiffened suspension bridges. This Chapter is very useful, as the majority of text-books on the subject are far too abstruse for the average reader. The so-called " approximate theory " is alone dealt with here, and, by its use, both truss and cable stresses can be computed with quite sufficient accuracy even for very large bridges with three, two or no hinges in the stiffening girders. An Appendix contains several charts to facilitate the calculations, and these should be of great assistance when checking designs. In Chapter II the various types of existing suspension bridges are discussed, and information is given upon the structural details and materials employed. Chapter III gives the complete computations for several selected type designs. Chapter IV deals with the methods used in the erection of suspension bridges, but is perhaps more of general interest than actual utility to a Royal Engineer officer, as the systems described are those employed upon larger bridges than he would be called upon to construct. The book, as a whole, certainly fulfils the author's aim in producing a practical hand-book on a subject which is often either omitted from other works or else dealt with in a purely theoretical manner. From the point of view of the average engineering reader the book is well worthy of note, if for no other reason than its Chapter describing in detail the erection of several of the longest single-spans in the world.

E.F.T.

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WORK OF THE R.E. IN THE EUROPEAN WAR, 1914–19.

MILITARY MINING.

THIS volume has been edited in three Parts: Part I—Historical. Part II—Mine Rescue Work. Part III—Technical. The author must be congratulated on the patience and skill with which he has compiled such an interesting and instructive account of the mining in France and Belgium, from the mass of correspondence and reports which had been accumulated during the war.

Mine Rescue Work is very fully described, although not strictly speaking R.E. work; but it must be remembered that the development of this science was absolutely essential to the success of our mining operations, and it has been wisely decided to ensure that the experience gained in this branch of mining should not be lost, by finding a place in a R.E. Publication for the contents of a pamphlet on the subject written by the expert Medical Officer specially attached to the Staff of the Engineer-in-Chief.

Part I, Chapter I traces the gradual development of the mining organization, from the blowing of the first mine of the war on our front about December, 1914, to the appointment of the Inspector of Mines' Staff at G.H.Q. and the subordinate staffs of the Controllers of Mines of the Armies.

The lightning speed at which the first eight tunnelling companies were formed is the strongest testimony to the fiery energy of Major Norton Griffiths (now Lt.-Col. Sir J. Norton Griffiths, K.C.B., D.S.O., M.P.) who, while personally escorting clay-kickers from England to the front by night, found time during the day to hold parades of men in the mining trade in every sort of unit at the front, and to select, by special charter, from A.G., G.H.Q., all or any of those men he considered suitable—a most remarkable charter, it must be admitted.

The tunnelling companies from overseas were a most valuable reinforcement. It was unfortunate that the mining situation at the front did not permit of the tunnelling units from each Dominion, etc., being grouped together in battalion formation. The staff of experts brought to France in the Headquarters of the Australian Mining Corps were of untold value.

The organization of the staffs for the Inspector and Controllers of Mines deserves study for use in the future. The reasons for the formation of these staffs were to obviate extravagant demands on the tunnelling personnel, to effect technical control over the work in hand and to ensure the economical distribution of the tunnelling companies.

At one time, in 1916, a rough census was taken of the men employed all down our front on underground work. It was found that as many as 24,000 all ranks was the highest number under the control of the Controllers of Mines.

These numbers included those men employed on dug-outs, but they indicate how the fighting strength of an army may be prejudiced by the too generous development of mining work.

The importance of the science of geology is very properly insisted upon and must never again be allowed to be omitted from any text-book

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on military mining. We were very heavily handicapped at one time by our ignorance on this subject.

Chapter II is a very able and interesting *résumé* of the development of the mining work from March, 1915—December, 1918, showing how the operations gradually improved from individual instances of mining spectacles and reprisals in shallow mines, in most unsuitable ground, to really important mining operations which formed a definite part of the scheme of a general offensive.

The only representative of the earlier period of mining included in the main operation of the Battle of Messines was the Berlin Tunnel at Hill 60. This was a long, inclined shaft to mine galleries 60 ft. or 70 ft. below the surface, driven through the wet clays overlying the good "blue."

This tunnel proved conclusively that an inclined shaft through wet clay is a very grave mining extravagance, for, when the incline was eventually superseded by a vertical shaft, the working party for pumping only was reduced by 70 men a day!

The organization of craters for defence is a most important study. The occupation of a crater is, of course, a tactical matter, but when the occupation has been decided upon, the actual organization of the defences is a highly technical matter and is, undoubtedly, work for the R.E. Time after time it happened that craters were blown for a definite purpose, which was fully achieved, priceless observation being obtained over the enemy trenches, but these craters never remained in our hands more than a few hours. The Germans, on the other hand, fully realized the value of such observation and made a point of occupying and retaining possession of nearly all important craters.

The mining under the Double Crassier at Loos is well told, but our success there does not appear from the text as important as it really was.

It will be seen from *Plate* IV that we occupied only 70 yards' length of the Southern Crassier. If this length had been taken by the Germans, they would have obtained observations over the whole of our trenches between Loos and Hill 70—which must have led to the evacuation of a very important portion of the ground won by the battle of Loos. It was essential that the German mining system should be destroyed, and the company which had this work in hand did it so thoroughly that the enemy never gave any more trouble.

The temperature of some of the headings under the Crassier was very high. This is said to be due to the effect of rain-water on the débris which formed the Crassier.

Chapter III gives detailed accounts of the more important mining operations which were undertaken in conjunction with a general action by other troops.

It opens with the mining for the attack on Hill 60 on 17th April, 1915.

This is the first mining operation of any importance in the history of the British Army since the Crimea and it is probable that the total charge fired was largely in excess of anything attempted in those days.

It was carried out under a R.E. officer, in accordance with the regulations and with the equipment of 1914.

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The complete success which attended the operation is an eloquent testimony to the efficiency of the designer and the personnel employed under him, for this work was done before the days of silent tramways and noiseless ventilating apparatus, and the science of listening was still in its infancy.

The result of the combined operation was neutralized not long after by the use of poison gas by the Germans.

St. Eloi.—A year after all but a month, mines were again used in combination with an infantry offensive in the adjacent salient of St. Eloi. This may be said to be the first mining effort under the control of the new mining organization. It is instructive to compare the depth of mines, size of charges, etc., with those of Hill 60.

Here again the operation, both from a mining and infantry point of view, was emminently successful, but failure to hold the craters as a second line to that consolidated by the infantry resulted in our capture of St. Eloi being annulled by the German counter-attack, and the Germans occupied the craters from which they commanded a view over our trenches until 7th June, 1917.

From the firing of these mines we obtained the first authentic description of the phenomena which accompany the firing of a deep heavy mine.

First the earth-shake, then the silent gradual growth of an enormous mushroom which soon disintegrates, falling outwards to form the lip, at the same time releasing the flames, gas, smoke and other products of combustion of the charge to form a pillar of fire and cloud to a height of 200 or 300 feet; lastly the pale-blue flickering flame which darts hither and thither like a will-o'-the-wisp, licking up the inflammable gases which escape as the débris settles.

The Bluff.—The description of this mining adventure is well worth careful study and those who have garrisoned the Bluff during 1916 will appreciate the action and, perhaps, recollect the officers of the Canadian Tunnelling Company who led the attack on the German System from " the top," after the successful blow of the flank-attack mines.

The accounts of entries by us into enemy galleries and *vice versa*, and the resulting underground scraps, read more like the description of a " stunt " film than real war, but they are none the less facts.

Chapter IV deals with the underground work carried out in connection with the Battle of the Somme.

This was of four varieties:—

(*a*) Mines for the destruction of enemy works.
(*b*) Galleries or Russian saps to provide advanced emplacements for machine-guns and Stokes mortars; these were to be prolonged to the enemy front line to form covered communication trenches across no man's land.
(*c*) Similar galleries for communications only.
(*d*) Similar galleries for emplacements only.

The mines which were fired at zero in close connection with the infantry attack were highly successful; the experience gained by the offensive at St. Eloi was thus confirmed. On the other hand, the Haw-

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thorne Ridge mine which was fired a few minutes before zero was of no assistance to the attack, as the enemy had time to occupy the lip of the crater before the infantry attack developed.

The Russian saps in the sections of the attack which succeeded were of great value, and in one or two cases were the only possible means of maintaining communication across no man's land for some considerable time.

Pipe pushing (a type of bored mining) was tried in High Wood and proved that this method was suitable during operations only when the ground was favourable. It is futile in a wood. Its use was afterwards confined to blowing short lengths of trench.

The mining at High Wood is an example of the wonderful spirit and determination to overcome all difficulties, by which all the tunnelling companies were inspired.

Chapter V deals with the preparations for the Battle of Arras and the Vimy Ridge.

In these operations offensive mines played a very small part, the efforts of the tunnelling companies being mainly devoted to the construction of subways, the value of which had been demonstrated on the Somme.

The main underground feature of the Battle of Arras was, undoubtedly, the development of the caves at Arras into subways and accommodation for the attacking troops.

The caves were discovered by us by accident, though the inhabitants of the town knew of their existence. They are in reality the series of underground chalk quarries from which, at a certain depth, chalk of sufficient hardness to form a reasonable building-stone had been extracted at various periods to build the town. The quarries ran roughly in the direction required and were of the greatest value, both as subways and as shell-proof shelter for troops.

From the plans it can be seen that, by connecting the sewer tunnel with the caves, the troops could walk under ground from the centre of Arras right into the German front line, a distance of nearly three miles.

Living accommodation was constructed for about four brigades of infantry.

An excellent account of these caves and tunnels is contained in the History of the New Zealand Tunnelling Company, by which unit this work was done.

On the Vimy Ridge the subways played a most important part, indeed. After the original attack on a portion of the front had been held up, the necessary reinforcements were sent up through a subway which took them under the German barrage and brought them out, untouched, in no man's land, whence they delivered the successful assault. Without the subway no reinforcement could have crossed the barrage.

The subways on the Vimy Ridge were not Russian saps; they were all constructed at shell-proof depth below the surface. It is unfortunate that there is no map showing the subways and where they were located on the length of front. Considering that the whole of the work was done under the close observation of the Germans from a crater which enfiladed our front and from which they could

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watch the daily growth of our spoil dumps, the successful completion of the scheme was a remarkable achievement.

Chapter VI is devoted to the description of the mining work for the Battle of Messines. It is not generally known that this work was commenced in October, 1915, when the Berlin Tunnel at Hill 60 was begun, and completed only a few hours before zero on 7th June, 1917. Permission to continue work on a system of purely offensive mining was obtained from the Commander-in-Chief in January, 1916, and from that date the plan which had its origin in the office of the Engineer-in-Chief at G.H.Q. in August, 1915, was pushed forward to its ultimate successful conclusion.

Of 24 mines which were completed, only one was definitely lost by enemy interference, four were not fired, as they were outside the zone of the attack of the 7th June.

The Germans knew that we were mining deep from their capture of our mines at Petite Douve farm, but they never discovered where we actually were, though they broke our galleries three times by the heavy charges they fired at intervals down their front. A great deal of trouble was taken in 1916–17 to conceal the fact that we were mining.

Their persistent activity at Hill 60 was an unceasing anxiety to the Controller of Mines Second Army, and the patient courage displayed by all ranks of the 1st Australian Tunnelling Company in spite of a heavy casualty list incurred above and below ground was beyond all praise.

The story of Messines mining is well told. It is a pity that through want of space many most thrilling incidents in the crowded life of the tunnellers have had to be omitted. All important details of the mines are given on *Plate* XVIII. A German authority stated at the time that the earth-shake of the mines was felt at Lille to such an extent that the inhabitants were seized with panic and German soldiers were seen running madly up and down the streets.

Besides the mines the tunnelling companies were employed in making underground shelters for headquarters of formations for use during the action. This was done on such a lavish scale that for the Battle of Messines, and the subsequent operation of the Fifth Army on the left, dug-outs were provided for every headquarters from battalion upwards.

This Chapter closes with a quotation from Ludendorff memoirs which is the finest compliment which has been paid to our "tunnellers" by the enemy in writing.

Another and almost greater compliment was the complete surprise of the enemy.

Though the work had been in progress for over 18 months, the mines were not openly talked of either at home or abroad. The tunnelling people proved that they could work and keep silent.

Chapter VII describes the work undertaken in connection with the offensive of the Fifth Army on 31st July, 1917. As stated above, this consisted mostly of making dug-outs.

The Messines mines had made the Germans very suspicious of any work which looked like mining. All dumps of blue clay were systematically shelled and work was delayed but never stopped.

Dug-outs in the canal bank meant for storage of pontoon equipment

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were thought to be mine shafts and effected the withdrawal of the German line on the canal, a distance of 500 yards, thus enabling our troops to cross the canal at zero without opposition. The Germans fired 14 mines in no man's land near our railway wood system, and reported that they had played havoc with our works. This was quite untrue, for, though we knew that the charges had been fired, we did not know where the craters were until they were depicted on an aerial photo, nowhere near any of our trenches or mines.

Chapter VIII closes Part I, with a description of the work done by the tunnelling companies during the period of open warfare, and from it a very good idea can be obtained of the versatility of these units.

Part I is illustrated by 40 Plates and Tables which, with the exception of the omission of the Plan of the subways on the Vimy Ridge have been well chosen for the purpose.

PART II.

Mine Rescue Work.—This Part is a condensed version of a very full report by Lt.-Col. D. Dale-Logan, D.S.O., M.D., R.A.M.C., who was responsible, under the Engineer-in-Chief, for the whole of the mine rescue organization throughout the war.

The treatise is a thoroughly up-to-date pamphlet by a practical expert in the science he writes on, and contains all the information necessary for the training of all those who in the future may have to undertake mining operations in war—without this knowledge no military mining can be thoroughly successful.

In successive Chapters the author deals with the investigation and selection of apparatus, discussing fully the relative advantages and disadvantages of the various patterns on the market at the present time and the relative value as gas detectors of mice and canaries; the organization of mine rescue work which deserves special study; the difficulties and dangers of rescue work in the trenches which is the outcome of actual experience gained in all parts of our front; concluding with a description of the German system of mine rescue compiled from captured documents and equipments, from which it appears that in mine rescue work, as in other things, the German started first and best and we ended up immeasurably superior.

The Illustrations and Plates are very clear and explain fully the text.

PART III.

Technical.—In this Part general principles only are dealt with. As may be imagined, since the personnel of the tunnelling companies was recruited from the mining profession all over the world, it was impossible to standardize details of construction—considerable control was exercised over the nature of explosive instruments, tools and equipment.

Chapter I deals with the general procedure in laying out a mine system. It must be understood that this idea was rarely possible. We usually took over a front which was already under attack by mining by the Germans, and the first thing our miners had to do was to try and make the position safe as soon as possible. When the situation was again normal, it became more or less possible to work on a plan.

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Chapter II describes the various methods of disposing the spoil from the face.

Every conceivable method of tramming, hauling, winding up vertical and inclined shafts and every method had its own devotees, but on arrival at the surface there was only one general principle which ruled the disposal, and that was, spoil heaps must be concealed.

The skill of the Germans in this respect was most clearly instanced when the German systems had been captured on the Somme front, where the locality of each British shaft was advertised by an enormous chalk mound, while the German shafts had to be marked with flags so that their position might be explained to the Inspector of Mines. Survey instruments were standardized to the Miners' Dial, theodolite and dumpy level, with prismatic compass and Abney level, as aids for hasty work. Accuracy in mining work is essential. As an instance of the importance of accuracy, it may be noted that, when the centre of Hill 70 system had been flooded, a mine already laid, and so placed as to wreck the most important branch of the enemy system if he should advance, was found by a boring machine worked at a calculated angle—the mine was actually fired by a small charge placed at the bottom of the borehole from a higher level and the delay caused to the enemy work was sufficient to enable us to make a new system and be ready to push back any attempt of the enemy to advance underground when he resumed activity. Without this result, which was entirely due to accurate survey, it is extremely likely that our infantry would have been blown off Hill 70.

As for ventilation, the Roots Blower was quickly found to be a source of danger, as the noise it made was a most unwelcome advertisement of mining activity.

The improvement in silent ventilation progressed with the improvement in listening apparatus.

Every sort of explosive was tried, but ammonal was proved to be the best for mining work.

Chapter III (Miscellaneous Notes) gives further details of the construction of subways which formed a very important item in the latter mining period.

Such systems as are described which run from Cuinchy to Hulluch can only be thought of when a front stabilizes for a year or more.

Comparison of British and German reports of the same mines is interesting reading and tends to show that both sides had the same optimism in claiming important effects of their own mines and never admitting that the enemy did them any harm.

Chapter IV is a detailed treatise on the subject of listening. It was in this science that the most remarkable progress was made. The first listening apparatus used by us was the Board of Trade microphone used by water engineers to detect a leak in a water-pipe. These were succeeded by French waterbottles which were filled partly with water and to which a medical officer's stethoscope was attached. The idea was developed into the Geophone which was the most useful and compact of the lot. This and the various electric listening-sets are fully described.

This Chapter is one of the most important in the book and should be specially studied. The degree of progress made during the war may be

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estimated by comparing the scale of distances in various ground with the fact that we thought 15-ft. thickness of clay would stop any sound, in 1915 !

The article on central listening must be regarded as an ideal which is very rarely possible; it was developed to a wonderful degree on the First Army front after the Germans' mining activity had almost entirely ceased; still, it is a possibility which should be noted.

The course of instruction in listening is important. Good listening is the foundation of safe and successful mining.

Chapter V gives in detail the organization of a mine school and the instruction given there. Mine schools are necessary to ensure that the standards and experiences gained during the campaign are passed on to the new personnel who come out as reinforcements and have no knowledge of the conditions of the front, however skilful they may be in their own calling as miners.

The details given are those of the First Army Mine School, and from them may be drawn an idea of what is necessary.

This part is also well provided with good Plates to illustrate the text.

Taken as a whole, this volume is a very valuable addition to any military library and, though many soul-stirring incidents have been crowded out, it can claim to be the plain unvarnished tale of mining on the Western Front.

R. N. HARVEY, *Maj.-Gen.*

MULTI-WHEEL AND TRACK MOTOR VEHICLES.

By MAJOR T. G. TULLOCH, late R.A. (Published by The Institute of Automobile Engineers).

THIS paper begins with the causes that are responsible for the breaking up and corrugation of modern highways, together with suggestions for bettering road transport.

Heavy commercial motor vehicles are shown to be responsible for the breaking up of good concrete roads built on ordinary subsoil. Overloads caused by the modern, heavy, four-wheeled commercial vehicle crush a slightly elastic road into the soft soil beneath. On the load passing, the road recovers itself, but the subsoil does not.

A gap is, therefore, left between the road surface and the subsoil. This gap gets bigger as more loads pass over the road and finally the road surface must fail owing to lack of support from beneath.

The cause of corrugations in roads is explained as being due to the vibrations in the road surface itself. A vehicle passing over a road causes it to vibrate, and at the same time a vacuum is caused in rear of the moving carriage. The heavier and faster the vehicle the greater the amplitude of the vibrations, and the greater the vacuum effect.

In the case of a road surface, the air that rushes in to fill the vacuum behind the vehicle encounters the surface of the road already in a state of vibration, and in consequence in a state of potential corrugation. Eddies

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are formed at once in the troughs of the vibration waves, and their circular scouring action at once lifts out any particles of disintegrated road material and displaces them. Thus the beginning of a permanent corrugation is made.

Opinions as to how corrugations are actually formed, and how road surfaces are actually broken up may differ, but it is generally admitted that the immediate cause of all road evils is the fast-moving commercial vehicle whose weight is concentrated on four points. It is this heavy spot loading that does the damage. Efforts to minimize the effect of this by pneumatic and other shock-absorbing tyres are only palliatives, and not cures.

The author puts forward as a cure for this heavy spot loading the principle of giving the road vehicle more wheels and suitable springing.

The De Mole eight or ten-wheeled truck is illustrated; the principle of its design being described as the greatest step forward in road vehicle design. The truck is provided with a large number of comparatively lightly-loaded wheels, the springs of which are prevented by chains or dash-pot arrangements from expanding beyond the flexion imposed by the load, whilst being open to further compression on encountering an obstacle. The result is that, in passing over a hole or depression in the road, the spring cannot shoot the wheel down into the hole, so that no damage is done to the road in the way of further enlargement of the hole by wheel impact on its further edge. At the same time, since the wheel is geared to the other wheels, it cannot spin freely while unsupported; no damage is done to the tyre when the level of the road is reached on the other side of the hole.

On the other hand, when passing over a lump in the road, the spring, being lighter than the ordinary type, will give easily without a tendency to lift the whole chassis. This means less wear on the chassis and fewer road shocks. Further, the wheels and axles being light, the unsprung weights are less—a most important advantage.

The steering permits the whole vehicle to turn in two-and-a-half times its own length.

A diagram is given, showing different road impacts for different vehicles. A multi-wheel vehicle with a useful load of $8\frac{3}{4}$ tons was passed over a 2-inch obstruction at $17\frac{1}{2}$ miles an hour; the maximum road impact was 7,000 lbs. An ordinary lorry with a useful load of 5 tons under similar conditions gave a road impact of 29,000 lbs. At the same time the running costs of the multi-wheel vehicle are less than those of four-wheeled lorry. The cost of moving a useful 8-ton load 1,500 miles in one year was, for the multi-wheeler, £1,162, while the cost of doing the same work with four 2-ton 4-wheeled lorries was £2,395. These figures prove that the multi-wheeler is cheaper to run and does less harm to the roads. The logical conclusion is, therefore, to use multi-wheelers with more and more wheels. But if this is done the wheels get small; therefore, they must be given a track to run on and, therefore, in the end you get a tracked vehicle.

The author, however, is not entirely wedded to the idea of the truck carrying its own track. He admits it is necessary for war, but does not

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admit that it is best for road work in civilized countries. Here he would prefer the multi-wheeler, his reasons being :—

(*a*) That the multi-wheeler is faster.
(*b*) That the tracked vehicle will wear out its tracks instead of the roads.

With regard to (*a*), vehicles with spring tracks have attained a speed of 27 miles per hour across country—fast enough for most heavy commercial trucks.

With regard to (*b*), this seems an advantage. In working out road repair costs, the author states that the owners of commercial vehicles who ply for profit on public highways pay 12 per cent. of the road repair bill and do 95 per cent. of the damage, the balance of the damage being made up by the ratepayer who gets no share in the profit. The railways have to lay and maintain their own track. Why not, therefore, make it compulsory for commercial vehicles to be tracked? In this way the cost of upkeep of track will be transferred to the right persons, and at the same time there will be a demand for commercial tracked vehicles which will be a potential war reserve.

The author states that the multi-wheeled vehicles are a half-way house between bad present practice and ideal future practice, but he would keep them for road work.

But why not strive now for the ideal, cut out the multi-wheeler and concentrate on the tracked vehicle as being the one and only suitable solution for both war and commerce?

G.C.G.

MAGAZINES.

REVUE MILITAIRE GÉNÉRALE.

(*February*, 1923.) *The Influence of Sports on Education for Action.* By Lieut.-Colonel A. P. Cour.—In the term "Sports" the writer includes all forms of physical exercise. Evidently a strong believer in exercise, he upholds the French method of lessons graduated according to age from primary for children, through secondary, to the severer forms only suitable for the more adult of 18 years of age and upwards. While giving England full credit for her people's addiction to sports, he considers that games are confined too much to particular classes. For France he would have more universal practice of games, so that by the time a man is called up for active service in the Army he will have received sound physical and moral training as a foundation for drill and discipline.

Those destined for the liberal professions, industry, and the Army must not jeopardize their intellectual development by too great attention to sports. For the higher Army commands, however, both are equally important. Command in war demands a good technical and general education with development of the critical sense, and at the same time the spirit of combativeness and initiative which is brought out by sports.

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He deplores the neglect of sports by the French *bourgeoisie*, and their preference for quiet, stay-at-home pursuits, while some of the universities even look on indulgence in sports as a wasteful expenditure of intellectual energy. Amongst the French there is a lack of the joy of living, as evidenced by the decline in the birth-rate, by their ceasing to compete with other nations in the modern economic struggle, by their having to employ native soldiers to defend their home frontiers, and by the fact that other nations are usurping their places in French colonies. But they are an old and warlike people, and the call of danger will find them standing ready. More time spent in the open air, either at rest or taking physical exercise, would raise the tone of the nerves of both men and women, give them a higher zest for life and its transmission, for facing the pangs of childbirth, and the trials of bringing up a family.

The general impression left by the perusal of this article is that, as a general rule, the French do not naturally turn to exercise, sports or games as a pleasant form of recreation, and that education to that end must be fostered in every possible way.

How the 29th Regiment of Chasseurs à Cheval Fell at Lille. By Commandant de Civrieux.—This article shortly describes the operations round Lille from 30th September to 13th October, 1914, when the town and small garrison surrendered. The Germans would hardly believe that the defenders were so few, and Prince Rupert of Bavaria personally returned his sword to the Commandant in recognition of the bravery displayed.

The Operations at Lodz in 1914. By Captain Salmon.—On the supposition that war with Germany may again break out, it is probable that neither side will at first have enough troops under arms to hold a continuous line. A war of movement for some weeks may therefore be expected. The object of this article is to show that, if Ludendorff pushes too far the Napoleonic doctrine of economy of forces, when he is opposed by more skilful leaders than the Russians had, he may run a very grave risk. In support of this opinion is taken the counter-offensive of the Grand Duke Nicholas immediately following the German attack towards Lodz. The situation on 10th November, 1914, is described. Briefly, Mackensen's army of 5 Corps was opposed to 3 Russian armies, totalling 12 Corps, yet by attacking with his whole force successive portions of the Russian armies, Ludendorff was at first successful, broke the Russian front, and caused the retreat of a considerable portion. After this, from 22nd November onwards, he took risks hardly justified even by the incapacity of some of the Russian generals. As a result, by the skilful dispositions of the Grand Duke, the German left wing was practically surrounded, but by dint of sheer hard fighting and an extraordinary night march through the Russian bivouacs, when the worn-out Russians took no notice of the noise of the retreating column, it was able to extricate itself. Ludendorff's confidence in himself and his troops was doubtless increased by this success, but it did not bring him victory when, in 1918, he engaged his last reserves in Champagne.

A Stage in the Pacification of Morocco.—This is the conclusion of the article by Captain Cagnat, and describes the operations from April to June, 1921. No incident of marked interest is related.

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Swiss Chronicle.—The military estimates for 1923 have been passed by the National Council for three million francs less than in 1922. To facilitate discussion, the Government circulated to the deputies a statement of the military situation, pointing out that Swiss neutrality was never respected except when the Army was strong enough to enforce it, and that preparation after the outbreak of war would be too late. Seven and a half millions are for the purchase of horses. Before 1914 remounts were obtained from Ireland, East Prussia, and Hungary; during the war from Spain and America. At the present time Ireland is the principal source of supply, the Irish horse possessing all the qualities desired, but purchases have also been made in France, and this source is worthy of development owing to the disturbed state of Ireland. The central cavalry remount depôt is at Berne, that for officers' chargers and artillery horses at Thonne. At the national horse show of 1922 a battery was shown horsed with *Franches Montagnes*, an improved breed of horses of the Jura strain, which may turn out entirely satisfactory.

Bibliography.—Ludendorff's *Conduct of War and Policy*, translated by Captain Koeltz (Berger-Levrault) is reviewed. It is said to be still more interesting and suggestive than its predecessors in that, more than they, it shows up the man and his principles. After four Chapters devoted to speculative considerations of war throughout the ages, the general raises the true question of his own conduct of the war in relation to politics. To exculpate the third great General Staff, to crush the civil power under the accusation of its sole responsibility for the final disaster, to throw into relief the personal work of the Q.M.G. by carefully refuting the attacks made against his former books, such are the true aims of this voluminous work.

Another book reviewed is Ludendorff's *Documents of the German Great General Staff*, Vol. II, translated by Battalion-Commander Delestraint (Payot). The first volume appeared at the end of last year as an Appendix to Ludendorff's *Memories*, and dealt with the part played by the G.G.S. and its chief in the home policy of the Empire. The present volume deals with their relations with foreign policy. The collection is of the highest historical interest, but in no way enhances Ludendorff's reputation.

A. R. REYNOLDS.

BULLETIN BELGE DES SCIENCES MILITAIRES, 1923.
(*Nos.* 1 *to* 4 *inclusive*).

The account of the operations of the Belgian Army during the Great War, 1914–1918, is continued in Nos. 1 to 4 inclusive of the *Bulletin* for the current year. Further details are given of the part played by the detached forts in the southern sector of Antwerp during the German siege operations, and of the effects produced on them by the German Heavy Artillery. The situation as it existed in Belgium at 5 p.m. on October 3rd, 1914, when the British First Lord of the Admiralty attended the meeting of the *Conseil de la Défense Nationale* held under the Presidency of King Albert is briefly described. Mr. Winston Churchill explained to

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the *Conseil* on that occasion that Great Britain could assist Belgium to the extent of providing 2,000 men at once (a Naval Brigade reached Antwerp the same evening); further, that 7,000 men would be forth coming within the next three days, and an Army Corps could be landed at Dunkirk within the next ten days. The question was whether Antwerp could hold out until October 13th: unfortunately, the situation was then a desperate one. The permanent forts on the front Walhem-Lierre were no longer garrisoned, but the line of the Nèthe and Rupel was still held by the Belgians, who had determined to hold on to it as long as possible, and eventually to make a stand, with fortress troops, along the parapets of the old enceinte. The decision had already been taken to send the Belgian Field Army south to join the French and British forces. The possibility of saving Antwerp, if it had ever existed, had by now completely passed away.

Capitaine-Commandant Paquot contributes an article to No. 1 of the *Bulletin*, on the subject of "strong points" based on the Belgian *Instruction provisoire sur le combat de l'infanterie*. The matters which require to be attended to in designing a network of "strong points" are dealt with in some detail in the original article, which concludes with a useful summary of the main features of such a system of defence works.

Colonel Fastrez contributes to Nos. 3 and 4 of the *Bulletin* an important and interesting article in which he shows how strategical and tactical problems are affected by the conditions of the epoch at which a conflict of arms takes place. For this purpose, he examines the various phases of the Great War of 1914–1918, and traces the influence of recent developments upon the strategy and tactics of the opposing sides: he then touches upon certain features of the last war with a view to indicating the influence which the more recent developments of the past decade are likely to have in a future war. In dealing with the Great War, Colonel Fastrez incidentally remarks that certain incidents connected therewith have, to some extent, resulted in a confusion of ideas as to the distinction between the two branches, strategy and tactics, of the art of war. The employment of what Colonel Fastrez calls the *arme-machine*, an expression intended to cover all the recent developments in armaments and everything connected therewith had, undoubtedly, a very far-reaching effect in the Great War. Germany's initial plan of campaign was largely influenced by the potentialities of the *arme-machine*: fearing that it would be difficult in the face of the *arme-machine* existing there to batter down the defensive barrier on the eastern frontier of France, the German General Staff planned that the German I and II armies should be the principal striking force, the *masse de manœuvre*, and should march through Belgium. It was hoped thus to turn formidable military obstacles on the eastern frontier of France, but the adoption of this course brought in its train very serious inconveniences of a political order, and really also, as it turned out, other complications which, to some extent, affected the strategical situation. The decision of the German General Staff alluded to robbed the Teuton strategy of flexibility right away in the initial stage of the war. The Germans were fully aware that the French intended in the opening phase of the war to assume the offensive with their right wing

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from the very part of the front they were shunning, and had taken the precaution of establishing in that region a thin defensive screen, but amply provided with the *arme-machine*. The French, it is suggested, underestimated the resisting power of this thin German line. The events that happened in August, 1914, on the Western Front demonstrate that the Teuton had assessed at its real value the *arme-machine*: the French First and Second Armies suffered heavy losses in their engagements with the German left wing and were held up. On the other hand, the German right wing was able to forge ahead, but the *arme-machine* at Liége upset the German programme and the original *manœuvre stratégique* designed for this wing had to be abandoned: moreover, an attempt made by the German General Staff to resuscitate the *manœuvre stratégique* failed. Colonel Fastrez argues that the operations subsequent to the Battle of the Marne in connection with the "Race to the Sea" do not fall in the category of strategic movements. The mere fact that troops were transferred from one part of the theatre of operations to another widely distant from it, involving the use of the railways and of automobiles, cannot, he thinks, alter the character of the movements, which were really tactical incidents in a battle fought over a widely-extended front. The first step, after the belligerents had settled down to trench warfare, adopted to bring strategy into play again on the Western Front was, according to Colonel Fastrez, taken in the summer of 1918, and not until then: this was when Marshal Foch, correctly appreciating that the heavy wastage suffered by the German armies during the offensives of March, April and May, 1918, rendered them incapable of effectively parrying a series of blows in quick succession, planned a concentric offensive along the whole German front. The principal feature of this offensive consisted in the repeated blows against the German front following quickly upon one another and delivered by assaulting troops which were supported by formations in reserve moved with great rapidity from one part of the front to another, as required, for the purposes of a definite scheme of attack. The operations in connection with this offensive fall, says Colonel Fastrez, in the domain of "grand tactics" rather than of strategy, but, although they do not constitute the *manœuvre stratégique*, they lie on the confines of strategy. Had Marshal Foch planned to drive the German pivot of retreat completely out of its place and thus turned the enemy's left flank so as to bring about a surrender of Germany's beaten forces, that, says Colonel Fastrez, would have been *une belle manœuvre stratégique*; had such an end been attained, there could have been no doubt but that the war had been fought to a finish and there would have been convincing evidence of the hopeless defeat of the Central Powers, much to the advantage of the future of Europe. In the events that actually happened it was a political act, and not a military one, that brought the World War to an end; it has created a dangerous and most unsatisfactory situation.

Among the other important features of the Great War upon which Colonel Fastrez touches are the economic and industrial factors which came into play and, at times, had a dominating influence on the course of events. As far as the economic situation in Germany was concerned, the presence of a German fleet in the Baltic, which it was difficult to put

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out of action, to some extent diminished the value of the blockade maintained against the Central Powers by the British and French Navies, which later were joined by the American Navy. Throughout the war, Germany was able to import much raw material, which was contraband, from and through Sweden and possibly Norway also.

Finally, very instructive is the forecast which Colonel Fastrez gives of the influence that continued developments in the use of poison-gases, aviation and tanks are likely to have in a future war. It is not possible to do justice to the subject in a short notice of this description.

In view of the immense importance of fuel oil for military purposes in a modern war, the articles on the petroleum question contributed to Nos. 3 and 4 of the *Bulletin* are timely. One has but to read the German technical papers dealing with the petroleum industry published during the war period to get an idea of how very great were the inconveniences suffered by the Central Powers, first, when the naval blockade cut off the American sources of supply of this important commodity, and later, when the Russian armies occupied the Galician oil fields: so inadequate was the supply of petroleum products in Germany at one time that researches were carried out with a view to discovering substitutes. Not only was it the Central Powers who felt the pinch owing to supplies from the United States being cut off, but the French were also placed in so difficult a position that Clemenceau, in December, 1917, made a personal appeal to President Wilson, asking him to divert to France the large quantities of petroleum which, owing to the greater safety of transport across the Pacific, were being exported to Asiatic markets. The original article contains, *inter alia*, information concerning the chief oil fields of the world, and technical information as to the characteristics of the oil produced there, and also statistical information.

Other articles deal with the handling of a Division (No. 1); "Tanks" (Nos. 1 to 4 incl.); Transport Corps (Nos. 1 and 2); the handling of an Army Corps (No. 2); the principle of the Battle (No. 3); the Cavalry question (No. 4); etc.

W. A. J. O'M.

REVUE MILITAIRE SUISSE, 1923.

(*Nos. 1 to 4 inclusive*).

Colonel Sarasin contributes an article to No. 1 of the *Revue* on the important subject of *l'exploration de combat*, which, for want of a more precise equivalent expression, may be termed "battle reconnaissance." He points out that it has always been necessary to base one's own tactical dispositions upon as full and as exact information as can be obtained beforehand concerning one's foe and the terrain upon which a collision of the opposing forces must take place—the Great War demonstrated the importance of providing a suitable organization for such a purpose. Colonel Sarasin warns us that, in spite of the enormous assistance to be derived in a modern war from aerial reconnaisances, the signal service, the "tapping" of the enemy's messages, etc., infantry advancing to the attack should never neglect the older methods of obtaining intelligence,

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e.g., by sending forward fighting patrols to pierce the veil which will still always cover the front of a skilfully handled force: he throws out some valuable suggestions relating to the organization of such patrols and insists upon the necessity of establishing "observatories" for the purposes of "battle reconnaissance." The subject is obviously of wide importance and requires to be treated not alone from the point of view of the infantryman, but also from that of the gunner, sapper and tank crew. Colonel Sarasin rightly points out that specially selected men should be detailed for duty in connection with reconnaissances of the kind dealt with in his article; that they should be correctly informed as to the situation of the troops for whom they are working as well as that of the enemy (so far as known); that they should be qualified correctly to appreciate the tactical features of the ground in all aspects. Although the author of the original article does not definitely so state his proposition, what it really comes to is that, in the case of the "battle reconnaissance," there should always be attached to a fighting patrol a few selected officers or N.C.O.'s of all the combatant arms, in order that they may each collect the information of the particular kind which is essential to their own branch of the service and will assist it efficiently to co-operate with the infantry in attack, defence or counter-attack. Obviously those detailed for so important a duty should always be provided with instructions in writing, setting out the particular points upon which they should concentrate their attention. Another article dealing with an important tactical subject is that in No. 4 of the *Revue* from the pen of the Colonel Turrettini, who discusses therein the question of effective *laison* between the infantry and artillery.

Nos. 1 and 2 of the *Revue* contain the concluding parts of the notices by Colonel Poudret relating to Grouard's *La conduite de la guerre jusqu'à la bataille de la Marne* and Hanotaux's *La bataille de la Marne*. The contents of No. 1 of the *Revue* are likely to prove of special interest to British soldiers; therein Colonel Poudret sets out the criticisms directed by Hanotaux against the British Commander-in-Chief and his handling of the B.E.F. Although the Higher Command is criticized, there is nothing but praise for the British soldier; it is recognized that the latter did all that he was called upon to do and did it splendidly. High praise is given also to Lord Kitchener for the part he played in December, 1914, in overcoming certain objections of Field-Marshal Sir John French to Joffre's plan of campaign. The view is expressed that the British Commander-in-Chief did not make the most of the opportunity which presented itself for the effective employment of the British Army at a critical period of the war. Several other points are touched upon, among them being the suggestion that at one time the subject of withdrawing the B.E.F. entirely from France was contemplated by at least one highly-placed staff officer. Rumours to this effect were afloat at the time, but the idea was entirely ridiculed in this country that such a step could have ever been in contemplation even in the mind of the most hopeless pessimist: Dame Rumour may, however, not have lived up to her reputation of being a "lying jade" on this occasion. Notices such as those of Colonel Poudret are of special value to the student of military history at the present time. The volume of literature relating

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to the Great War is already so great that even a man of comparative leisure has not sufficient time in which to study the contents of even the more important tomes being poured out by the Press ; a succinct analysis such as that contained in the articles under notice here cannot fail to be of very considerable assistance to those desiring to form conclusions of their own upon matters which are in controversy. It is particularly important that those who aspire to high command, or important staff jobs, should by study develop their critical faculties in relation to military questions, in order that when their " day " arrives they may exercise that sound judgment by which alone they can defeat their adversary. No better way exists of learning the true value of criticisms of the kind in question than by setting to work to dissect them, that is to say, than by becoming a master in the art of criticizing the critic.

Colonel Lecomte undertakes in Nos. 3 and 4 of the *Revue* the task of examining the criticisms which have been directed against von Ludendorff's strategy by General Buat and by his own countryman, the well-known Professor Delbrück: on some points these two writers are in accord. Delbrück is the more severe of the two; he charges von Ludendorff with having committed every conceivable strategical mistake, and holds him to be a man of mediocre intelligence only: indirectly then, the Professor pays an unhandsome compliment to the leaders who were opposed to the distinguished German Chief-of-Staff. Delbrück is of opinion that it was von Tirpitz and von Ludendorff who were responsible for the destruction of the Empire built half a century ago by von Bismarck and von Moltke, the Elder. As might be expected, a great deal of controversy rages round the German offensives of 1918. Buat, who has written a good deal on the subject, in no way attributes blame to von Ludendorff for having launched these offensives at the period that he did so ; however, he is of opinion that the most favourable part of the Entente front for such an enterprise was not chosen when the first blow was delivered in March, 1918. Buat considers that Amiens, the German objective was too distant from the immediate base from which the first offensive was launched ; he would have preferred the blow to have fallen on the part of the line near Lens, with the mouth of the Somme as the objective. At the conclusion of his article, Colonel Lecomte gives, in a short summary, his own views on the German strategy: he is of opinion that the fundamental idea of the German plan of campaign was quite sound, namely, first to crush France, and then Russia, while Great Britain was getting ready to play her part in the war. Neither Napoleon nor Frederic the Great would, he says, have disapproved of the German plan of 1914. The only question that arises in connection with the closing phases of the war is, he thinks, whether, after the blow to gain Amiens in March, 1918, had failed, von Ludendorff was justified in calling upon German armies to continue their effort by delivering the stroke of April 9th in Flanders, and that of May 27th against the Chemin des Dames. Colonel Lecomte unhesitatingly approves of the scheme executed by von Ludendorff in connection with these offensives ; it was based, he says, both on good strategy and on good sense: he analyses the situation, and shows that on May 25th the Germans still had the advantage of superior numbers, *i.e.*, 81 divisions

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against 67. However, when the Germans met with their check on June 15th, von Ludendorff should, in Colonel Lecomte's opinion, have realized that he could no longer hope to gain a decisive victory; in the events that happened, von Ludendorff, from that moment, ceased to play the part of a general and assumed the rôle of a dangerous gambler.

The article on the "Sixth Arm" by M. Jacques, begun in No. 9 of the *Revue* for 1922, is concluded in No. 1 of the current year. The author of the original article contends that the use of poison-gas in warfare is no more reprehensible or inhuman than that of many others of the means employed to destroy the morale of an enemy and to obtain the superiority over him: a soldier, who is "gassed," is a victim of war entitled to no greater compassion, he argues, than the soldier wounded by the explosion of an ordinary shell. M. Jacques considers that the condemnation of gas-warfare is illogical and not based on a sound knowledge of the true effects of poison-gases: the "chemical arm," according to him, came in for universal reprobation during the Great War alone, because, in using poison-gas, Germany was guilty of a flagrant violation of engagements entered into by her at The Hague. In support of his contentions M. Jacques quotes American statistics and claims that these demonstrate that, whereas in the case of wounds caused by bullets, shells, explosions (including mines) and the *arme blanche* 30 per cent. proved fatal, in the case of soldiers gassed 1·5 per cent alone died; allowing, he says, for deaths that have taken place since the armistice, "chemical warfare" was responsible for 50 per cent. fewer victims in proportion to those caused by all the other weapons of war put together. M. Jacques is satisfied in his own mind that "chemical warfare" has come to stay and, in consequence, urges those whose duty it is to prepare for the next great conflict of arms to pay more attention to the scientific elements that play a part in war and less to matters connected with "drill."

The remaining articles in the Nos. of the *Revue* under notice deal, *inter alia*, with the problem of the "conscientious objector" (No. 2), the conversion of the mountings of the Swiss 75 mm. gun (No. 3), the bearing which emigration has on the problem of national defence (No. 4), and questions affecting mountain artillery (No. 4).

W. A. J. O'M.

HEERESTECHNIK.

(*February, March and April*, 1923, *numbers inclusive.*)

CAPT. JUSTROW continues his article on the theoretical conditions affecting the life of barrels. The complete series will evidently form an important volume, which is to be published presently by "Offene Worte." The mathematical conclusions are well illustrated by diagrams and equations—and these and references to former works on the same subject will be of value to a serious student. Some sample computation is given in the April number. There is nothing in these articles of peculiar interest to the Corps, however, and discretion being the better part of valour, it will be as well to leave to the regiment a more detailed examination.

Major Klingbeil continues his article on the construction of fortifi-

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cations in sand-dune country. He gives examples of the burying by sand of observation and position-finding stations. In a discussion on protection he divides his types into those which are rigid and absolute wind-screens, such as walls, those which are penetrable by wind and non-rigid, such as hedges, and those which are at once penetrable and rigid, such as post and rail fence. The behaviour of driving sand results in the curious fact that sand driving against the first type piles up some way in front and leaves a deep trench-shaped hollow along the foot of the wall on the windward side. In the second type the sand piles high immediately to leeward of the hedge, falling gradually and evenly away. No trench is formed. In the third type a parapet forms with crest line coincident with the fence. Natural wind-screens, such as trees and bushes, are strongly advocated—and various hardy grasses and " bents " suitable for fixing the sand in position are described. The mere deflection of the sand invasion may cause unlooked-for damage to others—and it is considered wise to unite the interests of the neighbourhood. The greatest difficulty is to keep in place the sand which covers concrete aprons. A list of such grasses as will grow on so shallow and unstable a bed is given. Paths and roads should be curved, so as to avoid the usual direction of the wind.

In the March number the movements of sand below high-water mark are considered. Broadly, the deposit of sand by water follows, as it does by wind, in accordance with the penetrability and rigidity of the obstacle. The use of groins, sea-walls, etc., is dismissed somewhat curtly, but it is a subject amply dealt with already.

Major Malbrandt contributes an article on bridges, flying bridges and fords, which outlines the instruction he recommends for officers in charge of mechanical transport. A knowledge of the simpler rules and formulæ is necessary in order to be independent of technical help. A list of the points to investigate in various types of bridges is accompanied by a précis of the precautions to be taken in crossing. The article does not go deeply into the subject but does give a common-sense and useful syllabus. There are several other articles in the " official " section which are of no particular interest to the British Army.

In the " unofficial " section Lieut.-General Schwarte takes up his description of the storming of " Camp des Romains " with the advance of the 1st and 2nd Battalions of the 11th Regiment to within 1,500 metres of the Fort. Ladders, planks, ropes and pliers were brought up by the Prussian Pioneers and not a shot was fired, until the Pioneers advanced further in the belief that the fort had been abandoned. The assault was ordered for 5.30 a.m. on the following day, and eight company columns were detailed—three for the north side, three for the south, and one each against the east and the south-east corner. Detachments of Pioneers were detailed for each column. Ladders and hand grenades were issued after dark, and the columns moved forward to assaulting positions. It was not until the cutting of the wire began (under heavy rifle fire) that reports were received to the effect that fort, wire and trenches were practically undamaged and that the French were in force and ready for the attack. The columns detailed for the southern front reported that the 28-cm. mortars were getting mostly over on to the

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southern glacis, and that wire-cutting was impossible in consequence. The outlook was unpromising, but a delay undesirable, so at 5.30 the assaulting columns moved out and effected so complete a surprise that the wire was past, ladders erected and a lodgment effected in the fort itself before a shot was fired. At this point a dog appears to have emulated the geese in the Forum; the defence awoke to the situation and for three hours with machine-gun, bomb and bayonet kept the attack within bounds. At 8.30 the Commandant surrendered the fort and secured for the garrison the privilege of marching out with military honours. The German artillery comes in for some criticism. The observation of fire was poor and the effect of the heavy mortars much below expectation. The old masonry fort, however, is more difficult to breach than had been anticipated before the war. The troops were quite new to siege warfare, and the lesson which the author desires to preach (that is, a preparation in peace for a type of warfare which will be inevitable in the future war) is finally insisted upon. The principal lesson of the operation, as described in this article, however, would appear to be afforded by the lack of alertness in the defence.

Lieut. von Stammbach discusses the repairs to heavy iron bridges which can be executed by pioneer battalions. There are obvious advantages in eliminating calls for civil engineers, as the situation is grasped quicker, and something solid is sooner achieved, even if not in theoretically proper proportion. The necessity of a clear waterway below and the labour of excavating deviations often impose a reconstruction. By substituting struts for ties, wood may often be used. Field units can generally count on being able to lift up to 200 tons with the facilities with the troops, or to be found in neighbourhood of the bridge. It is often desirable to limit reconstruction to the smallest width possible in order to eliminate the heavy and lengthy task of replacing portions of piers, driving new piles, etc.

Following on a controversy in the *Artilleristische Monatshefte* with Lieut.-General Rohne, Capt. Justrow contributes two articles which maintain the superior effect of shell splinters over shrapnel upon the majority of war targets. Shrapnel are wanted, but in smaller proportion than heretofore. If hits by splinters are fewer, they are much more likely to be fatal or crippling.

Major-General v. Borries writes a critique of the fourth volume of *Der Grosse Krieg*, 1914–1918 (M. Schwarte) which has recently appeared and includes parts dealing with naval air and gas warfare as well as with the campaigns in Asia Minor, Gallipoli and the German colonies. The enormities and the lies of the less-cultured allied armies appear to find considerable expression. It is impossible to judge the book by this critique, which is itself an *ex parte* statement.

Extracts from the 1920–21 report of the German Survey are interesting. They hint at a new national 1/50,000 map, or, at any rate, at certain experimental sheets. The question of copper engraving *versus* heliozincography is being investigated, and the use of a decimally-divided degree is also raised. It will add one more horror to life if we have to think in thousandths of a degree as well as in established grade and sexagesimal systems.

H. ST.J.L.W.

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MILITAR WOCHENBLATT.

(*21st October*, 1922.)—In a condensed but lucid account of the recent Greco-Turkish war the writer of the leading article in this number sketches the main events, their causes and effects, from May, 1919, to the conclusion of the Mudania agreement. It is interesting to observe the hand which the writer of the article thinks to have been played by the Allies, and particularly by England, in this Greek gamble. He begins by saying that one of the most important aims of English policy in the Great War had been to secure unrestricted mastery of the eastern portion of the Mediterranean by means of the disruption of Turkey into small, powerless states. The issue of the war had deprived Turkey of its vast Arabian territories. Anatolia had remained the centre of the Turkish state. Although Turkey had been sorely weakened by the wars of the last ten years, there remained, nevertheless, the possibility that she might regain her strength at no very distant date. How this was to be brought about the writer does not say, but English policy after the war was directed to preventing the possibility of this resurrection, and found a willing partner in Greece. With the watchword of "Liberation from the Turkish yoke" for the Greeks living on the coast of Asia Minor, the Greeks, in May, 1919, occupied Smyrna "without a previous declaration of war;" they hoped that consideration would be given to the national claims in the peace to be concluded with Turkey. But Turkey showed herself not so powerless as the Great Powers and Greece had assumed her to be, and the Angora Government was set up under the energetic leadership of Mustapha Kemal in opposition to the Government in Constantinople. The Angora Government succeeded, in a short while, in making its influence felt over nearly all the territories which yet remained to Turkey; it was firmly determined not to submit to a peace dictated by the Entente. For the latter, therefore, there remained no other course but either to recognize the claims of the Angora Government or to compel it, by force of arms, to accept the proposed conditions of peace. At the instigation of England the Entente adopted the second alternative, and Greece was commissioned at the Hythe Conference in May, 1920, to bring the Angora Government to reason by an offensive to be launched into the interior of Asia Minor. So much for the writer's idea of the political causes of this war. The events are then described with reasonable fairness. For the Army collected by the Greeks in Thrace in the summer of 1922 the writer points out that 15,000 men were withdrawn from Asia Minor. The Greek project of an advance in the direction of Constantinople was vetoed by the Entente. The repeated representations of the Greek general in Asia Minor to the Government at Athens that the front should be withdrawn in view of this reduction of troops met with no response. After describing briefly the Turkish successes of August–September which then followed, the writer goes on to say that after the collapse of the Greek army England recognized that she must herself take an active part if she was to attain her aims in Asia Minor. On 5th September she asked the Dominions, her Allies, France and Italy, and even Rumania and Yugo-Slavia to take their share in the defence

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of the Straits, if need be, against attack by the Turks. France and Italy declared their wish to remain neutral in the event of a war between England and Turkey. The attitude of both Balkan States was doubtful. Even Canada and South Africa "declined to send troops." England was therefore faced with the question of undertaking alone the defence of the Straits. English naval and military reinforcements were sent to the Straits. After describing the political events that followed, the writer goes on to ascribe to M. Franklin Bouillon the success of arriving at an understanding with the Turks, from which the Mudania Conference resulted; the tension between France and England is made much of, agreement being arrived at, according to the writer, by the adoption of a middle course. The main points of the Mudania agreement are then given. Not a word is to be found of the influence of General Sir C. Harington on the proceedings, while the whole tone of the article displays the desire to belittle British policy and activities in the Near East.

In an article on Danish Army Organization there is the following conclusion:—"The Danish Defence Force has, by the new law, experienced a not inconsiderable increase of strength as compared with recent years. There is not a sign of any disarmament as against Germany; on the contrary, the illegitimate profits arising out of the Versailles Treaty (*Gewaltdiktat!*) force Denmark to a continual state of preparedness for war which should prepare for the little country much breaking of heads in the future.

M. Poincaré's repetition of the accusation of "disciplined barbarity" against the German troops, in his speech at Bar-le-Duc on 20th August, 1922, has drawn an official reply which is communicated to the *M.W.B.* and published in this number. It contains nothing of much interest; protest is made against making a whole army responsible for the deeds of a few, and the usual accusation of crimes committed by soldiers of the Entente is repeated. The writer concludes by saying that speeches such as M. Poincaré is continually making can only do harm at a moment when every effort is needed to prevent the economic break-up, not only of Germany, but of all the European States that stand in close relationship to her. The home-truths about the German war criminals have evidently an exasperating effect, which it is apparently sought to correct by violent counter-propaganda.

1st November, 1922.—The leading article of this number deals with the account of the landing at Suvla Bay in August, 1915, as culled from *The Times*. No comments are offered, though the account is given with a Turkish bias. "All the English attacks were shattered by the heroic resistance of the Turkish troops."

In a "military political" article on Denmark, Norway and Sweden, General von Winterfeldt points out that the redistribution of the Danish army has an offensive direction against Germany, the Danish minister president basing the reasons for the changes on Denmark's position in the League of Nations, which may force them to the defence of their neutrality and to eventual participation in international expeditions. To which the General provides a mark of exclamation. He notes in Denmark's external policy a certain *rapprochement* with France, though

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no definite undertaking has been concluded. French capital is seeking to exploit Danish munitions industries and to fit these for the production of results which have hitherto been impossible.

Under the title *Night, Mist and War* a reserve lieutenant stresses the need for special training for night-work, particularly in the case of the town-bred soldier, whose ability to find his way about in the dark was proved in the war to be *nil*. He fell over stones and hollows which the countryman was able to perceive and feel. He fell into holes and ran up against standing wagons which the other was able to avoid. He adds even that the country-bred soldier lacked training in night-work. Difficulties by night were accentuated by rain or snow. He points out that this was bad enough when it was a matter of bringing up rations or ammunition, but disastrous in the case of telephone linemen or " runners." He cites, as the most striking case in the late war, the attempt at Brzeziny on 23rd November, 1914, to get the orders of the 25th Reserve Corps for the next day through to the 3rd (Guard) Infantry Division. A captain of the General Staff, a whole squadron and several dispatch-riders were tried in vain. To see in the dark, to be able to find one's way about the country, to find troops or villages, to carry orders through, these must be systematically practised. He concludes by urging that these aims may be contributed to by training the youths in their young men's clubs (*Jugendvereine*) to being accustomed to the dark, a proceeding which he claims in no way contravenes Art. 177 of the Peace Treaty!

11th November, 1922.—" Lucius Cincinnatus " contributes, in the leading article, a so-called " military political " review of the general world situation. With the exception of a few lines on Eastern Siberia, the article is devoted to European affairs and mainly to a violent tirade against the military commission of control. The iniquities of its president, General Nollet, are described with a wealth of epithet, the reason for the outburst being the suggested substitution of a " military guarantee committee " for the present commission.

After some comments on the introduction of 18 months' service in the French Army, he then turns to the change of government in England, which, he says, has been welcomed in French military circles. He quotes a severe criticism of Mr. Lloyd George by General Fouville, adding that whether Mr. Bonar Law will find more favour in this critic's eyes is yet to be seen, and only then, provided he will consent without conditions to every intransigent demand, of the French in particular, for the enslavement of Germany. The new Prime Minister's first speeches make the writer doubt whether the change will benefit Germany. He then goes on to say that the leading English Jingo paper, *The Times*, has just published a whole string of lies about the *Reichswehr* in order to prove that Germany is training more soldiers than they are allowed, and has only temporarily pensioned officers who are to be promptly reinstated, and so on. England's first task after the Turkish victory over the Greeks is to deal with the liquidation of the Near East question. Mr. Lloyd George backed the wrong horse, and obviously did not appreciate the military weakness of the Greeks, or he would have pursued a different plan on the Bosphorus. " The English plan of creating in the Eastern

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Mediterranean a Greek *mare clausum* under British control has been demolished for the time being," but he thinks that we have not finished with it, as witnessed by the stubbornness with which we stick to our intentions and the means we have got at our disposal there. " Great Britain has still some trumps in her hand, not only her influence in Greece, but also her position in Crete." He finishes by eulogizing Mustapha Kemal, who has played the decisive rôle in the conflict.

A review of the ex-Kaiser's book of experiences, 1878–1918, affords an excuse for asserting Germany's innocence for starting the Great War. This review is followed by a report of evidence given before the Commission appointed by the *Reichstag* to investigate the causes of the German collapse in 1918, at the beginning of which we find that the first witness proves that the ex-Kaiser must bear not only the formal but the actual responsibility for the offensive of 1918. The third witness, Prof. Delbrück, considers that the fatherland was sacrificed to Ludendorff's ambition. Rathenau, though criticizing Ludendorff, condemns the system and not men. The article summarizing the disclosures says that Ludendorff was not opposed to a so-called " peace by consent," if only there was the slightest prospect for it. As no such prospect was apparent, at least to him, he had no other course but to appeal to the fortune of war. He believed in victory, in his star. It ends by quoting Prof. Delbrück himself: " Did Hannibal lose one whit of his greatness because at the end the forces of the Romans were greater than he had calculated and the Carthaginians were defeated? "

" The Problem of the Professional Army " is the title of an article which sets out to answer the question of maintaining efficiency in the rank and file during the long period of colour service; " twelve years of ' slope arms ' and ' order arms ' pass the limit of bearable boredom." The experiences of other countries are only of value up to a certain point; colonial service affords the necessary change for the English soldier. The methods of the Foreign Legion are not such as the German would apply(?). The writer then goes on to advocate the abolition of all duties and parades which a long-service man does not need; for instance, no reveille on Sundays, half-holidays from time to time, and to slacken rein between two strenuous parades. He then sketches in outline a suggested course for the infantry-man, the main points of which appear to be to train all men to the light machine-gun, a large proportion as machine-gunners and trench-mortar experts, and the whole as potential N.C.O.'s. As regards this last point, the attitude is curious, though perhaps natural in an army with their traditions: the man promoted, as suggested, at the end of his fourth year of service to be a N.C.O. is suddenly placed over the comrades of his own year and over those of longer service who have not received promotion. " These will, at first, submit themselves only reluctantly to his orders." It will be even more difficult for anyone promoted Company Serjeant-Major while young. " Theoretically, change of Company on promotion would be the best solution. But then no Company Commander would take any interest in pushing on his best men." The most difficult question is regarded as that of soldiers' marriages. He does not want to see a force, the greater half of which consists of conscientious fathers of

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families, but, on the other hand, the State cannot prevent the soldier from marrying throughout his service. Young and efficient soldiers are apparently already seeking their discharge on account of the impossibility of marrying, and such cases will increase as time goes on. Why marriage " off the strength " is not possible is not explained. After mentioning a few more apparent difficulties, he concludes by urging the Corps of officers to tackle the question in detail.

21st November, 1922.—The leading article consists of a reply by General Ludendorff to the criticism of " double vision " levelled against him in the evidence given before the *Reichstag* commission. The charge against him was that outwardly, from various motives, he pursued different aims to what he considered possible of attainment, and had been more prepared for making peace than he showed. A further deduction is made that he regarded the situation as desperate, continually " trembled for peace " and only continued to prosecute the war out of personal ambition. Against this he asserts that he was always in agreement with the policy of seeking a reasonable peace if it was attainable, but he never believed in its possibility, yet was in duty bound not to hinder the Chancellor from pursuing it if the latter thought it within reach. As long as there was no peace, they had to fight on for a victory if that was possible. The conditions in the autumn of 1918 he promises to deal with later.

" In the summer of 1917 England was said to have been ready for peace, that is to say, to feel herself too weak to continue the war with the prospect of attaining her goal, the destruction of Germany, and to fear that she herself might be beaten. I welcomed the corresponding communication concerning England's peace move most gladly, though with doubt." He saw that it was hopeless, under the then conditions, to secure by this peace the establishment of their position on the Flanders coast, but thought they could establish themselves on the Meuse by Liége, which did not vitally affect England's interests, supposing she was really ready for peace, that is to say, weaker than they assumed. At the Council of 11th September, 1917, the Emperor opposed the proposal concerning the Meuse, and gave the Secretary of State, von Kühlmann, full authority to guarantee the sovereignty and full restoration of Belgium in case peace was concluded in 1917. For the rest, the Secretary of State was given a free hand for his activities. In Berlin circles there was the belief that an open declaration concerning Belgium, in the sense of the Imperial decision, might be the key to peace. There then follows a long story of the action of General von Haeften, Ludendorff's representative in Berlin on many questions, in proposing to von Kühlmann that the declaration about Belgium should be published ; the proposal was rejected. Ludendorff says he refrained from blaming the general for thus acting off his own bat, as the only result of it had been to show the Secretary of State that, in conformity with the Imperial decision, German G.H.Q. left him free to pursue any course which he found convenient. German G.H.Q. was not in a position to influence directly the action of the Secretary of State ; its job was to win the possibility of peace by fighting, knowing nothing of its details. For it the knowledge sufficed that, so far as depended on

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G.H.Q., it had removed every difficulty from the Foreign Office in this matter. He defends the bringing up again of the question on the 14th September by saying that G.H.Q., as there was no protocol, considered it necessary to lay down clearly its views for the probable case of there being no peace concluded in 1917, and the Secretary of State's full powers in this matter being withdrawn. G.H.Q. was clear that speeches about war aims had only the object of finding a basis of negotiation in the given military situation. What would be achieved depended, apart from the military situation, upon the strength of the German representatives at the conference table. " The confidence of G.H.Q. in this strength was uncommonly small." There follows a paragraph dealing with " the weak government," " its internal defeatist policy," " party business," ending " for the war aims, like everything with us, had become a question of internal politics, whereby the conduct of war and its essential meaning were forgotten, until, by the dagger-blow and revolution, the collapse arrived."

In the position German G.H.Q. took up with regard to the so-called English peace-feeler no other considerations played any part, not even the feeling in the higher staffs, which for the most part was very yielding; on this Ludendorff says he had no doubt as a result of his many journeys to the front.

" It is clear that in this general situation the war was to be pushed on with energy and pursued without interruption." Ludendorff thus claims this to have been his " double vision " in the autumn of 1917. The position taken up by G.H.Q., he says, is simple, clear and logical, free of prepossessions and contradictions.

1st December, 1922.—Ludendorff continues his reply to the accusation of " double vision," in a long article dealing with the situation in the spring of '18, which he begins by saying was such that they could assume the offensive in the west with a prospect of success. He condemns the diplomats for their weak and undecided attitude at Brest-Litovsk and Bucharest, which had not helped the military leaders, and for their failure to get into touch with the western powers. G.H.Q. was only aware of preposterous peace conditions which could not be accepted except by a defeated Germany. Of other unacceptable offers, like Clemenceau's to Count Czernin, G.H.Q. heard no word; the continuation of the war was all that remained. After another dig at the diplomats over their hesitating attitude in the East, the obscure conditions there and the Ukraine enterprise, he says that G.H.Q. was well aware of the extent and difficulty of its task in attacking in the western theatre, and had paid due regard to it by preparation and training of the troops. Report was made to the ex-Kaiser that the army was well equipped and prepared for the greatest task of its history. " An elevated, moral earnestness inflamed G.H.Q."

Their idea was to reach a decision by a " tactical victory," if not at the first, then at the second attack, in the course of which the Entente, before the arrival of the Americans in decisive numbers, was to be brought to the position of seeking peace, and thus to save Germany; delay would spoil everything. For such a tactical victory the enemy's front must be penetrated so far that a break-through must result, giving

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them freedom of operation against the exposed hostile wing. The first thing then was to find a weak spot in the enemy's front which promised such a success. " This was found south of Arras on both sides of St. Quentin, offering an attack in the direction of Amiens, that is to say, separating the French and British forces."

An attack in Flanders was also contemplated, and in the plain of the Lys. " To roll up the enemy's front from the north, after the style of the 1914 operations, was attractive." These operations, with their own right wing supported on the sea, was, he says, much easier than that towards Amiens. " But in view of the distribution of the enemy's troops the tactical success of the attack seemed by no means probable " ; conditions in Flanders were " still more unfavourable " than they were at the attack of the 17th Army on 21st March, and the latter had but little success, though outside circumstances may have had something to do with it. It is difficult to draw comparisons, especially between tactical situations, but still one can get at essential facts which deserve a certain consideration.—(*To be continued.*)

E.G.W.

CORRESPONDENCE.

THE DRAYSON FALLACY.

SIR,

In the last number of the *Royal Engineers Journal* you printed a review, by Colonel B. R. Ward, of a pamphlet entitled " The Drayson Problem. His Important Astronomical Discovery." By chance I have had the opportunity of reading the pamphlet, and I find that the author avows himself to be an astrologer, or, in his own words, " attached " to astrology. He doubts whether the earth is really an oblate spheroid, and says that " the settling of this question is not easy, since the equatorial protuberance (if any) is so slight." He states that the proper motions of the stars, " at present assigned, do not result from any motion of the stars, but from a motion of the earth improperly conceived." He is of opinion that the motions in the line of sight, derived from spectroscopic investigations, should not be accepted, since they are really due to the prepossessions of astronomers. And so on, and so on.

On first reading Colonel Ward's review one might, perhaps, get the impression that he approves of the fallacy and of the conclusions of the author. But probably a juster view is that Colonel Ward is indulging in what is familiarly known as a "leg pull."

F.R.A.S.

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THE EMPLOYMENT OF DIVISIONAL ENGINEERS IN CONJUNCTION WITH OTHER ARMS IN WAR.

SCHOOL OF MILITARY ENGINEERING, CHATHAM.
14th April, 1923.

SIR,

In the March number of the *R.E. Journal* you published a letter from Brevet Major H. C. B. Wemyss, Royal Corps of Signals, in which he disagrees with my contention that an independent system of engineer communications is essential to the efficient working of the system of Divisional Control of Engineer Work as enunciated in *Engineer Training*, 1922 (*Provisional*). May I be permitted to say a few words in self-defence?

Everybody now agrees, I think, that all communications *except within units* should be in the hands of the Divisional Signal Company. But he goes on to say that the "unit," in the case of the engineers, is the Company. There I disagree with him. Under the Brigade Group System the Company was the unit. Under the Divisional System the "unit," so far as tactical control is concerned, is the divisional engineers, *commanded* by the C.R.E. If you deny to a commander of a unit his own means of communicating his orders to his sub-units he cannot efficiently command them, nor can he be held responsible for any failure due to non-receipt of orders. The motor-cyclists of the field companies and the C.R.E. correspond to the runners and signallers of an infantry battalion. Without them the battalion commander cannot exercise his functions of command, nor are they provided by the Royal Corps of Signals. The C.R.E. is in the same position. The argument of Major Wemyss, therefore, though sound in itself, is based on a false hypothesis which vitiates his conclusions.

The Rawlinson Committee on the organization of the engineers of the Army allowed the following motor-cycles for intercommunication purposes in the units of divisional engineers in the establishments it recommended:—

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3 Headquarters Double Field Company (2 each)	6
6 Headquarters Field Company (1 each)	6
Total for Divisional Engineers	14

Yours faithfully,
G. E. H. SIM, *Brevet Major.*

The Editor, *R.E. Journal*

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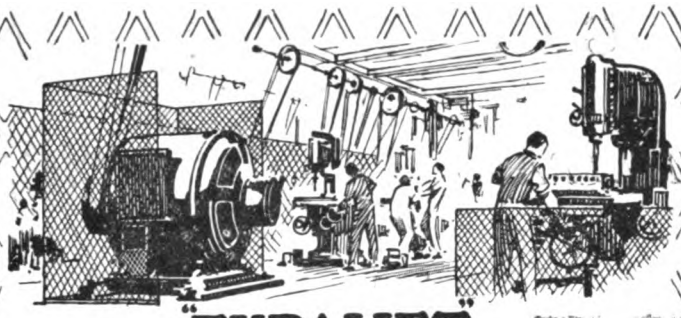

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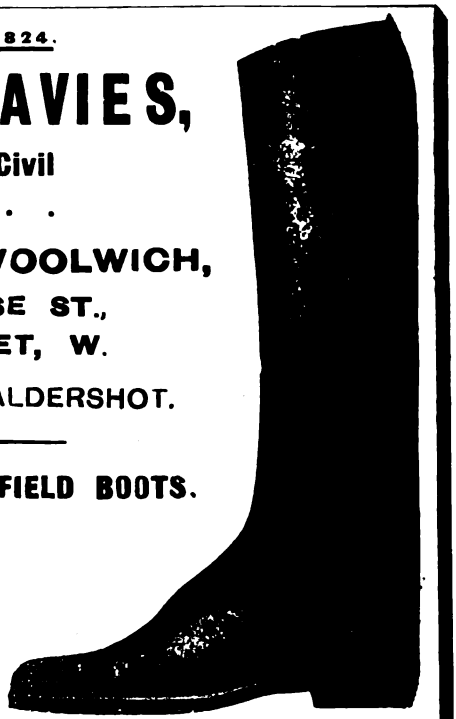

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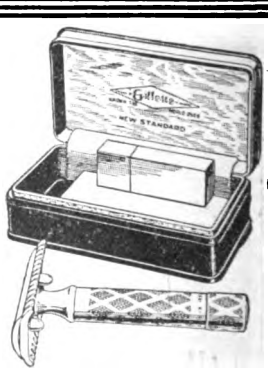

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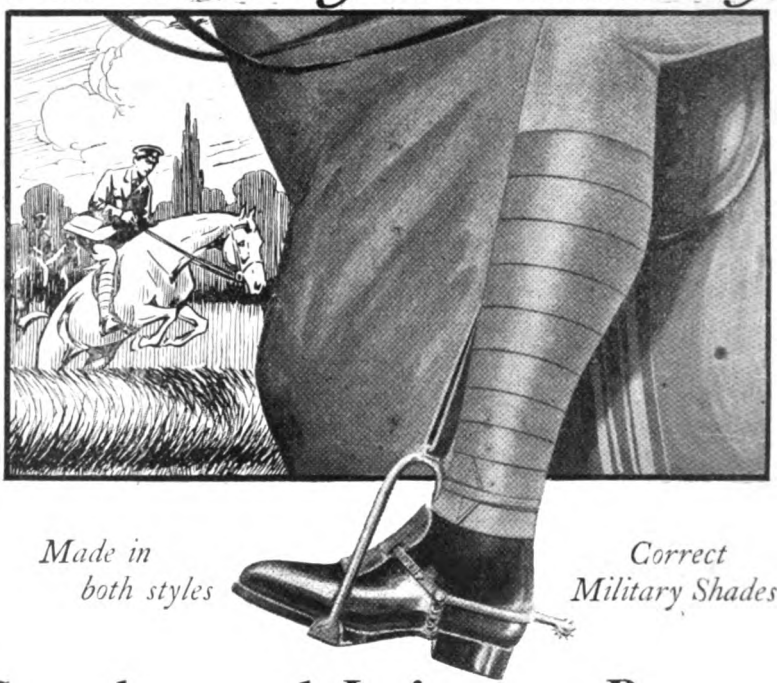

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MOUNT EVEREST.

By MAJOR H. T. MORSHEAD, D.S.O., R.E.

THE following notes by one who had the privilege of serving as a member of the Expeditions of 1921 and 1922, have been written in response to a request from the Editor of the *R.E. Journal* for an article on Mt. Everest. It is hoped that the subject, though devoid of any technical or military importance, may yet, perhaps, prove of sufficient general interest to appeal to readers of the *Journal.*

Permission to use the accompanying maps and the illustration "Mount Everest at Sunset" has been kindly given by Mr. A. R. Hinks, C.B.E., F.R.S., on behalf of the Mt. Everest Committee, the owners of the copyright. It will be noticed that the spelling of place-names on the maps differs in certain cases from that used in the text—the latter being the form accepted by the Survey of India.

INTRODUCTION.

Mt. Everest is situated in latitude N.27°:59′ and longitude E. 86°:56′, on the main axis of the Great Himalaya Range which here forms the Indo-Tibetan frontier. A glance at the map of India will show that here, in the neighbourhood of Sikkim and Eastern Nepal, the Himalaya undergoes a marked change of direction; after trending for 1,000 miles in a general east-south-easterly direction, the mountains in this region turn due eastward, or slightly north of east, for a further 500 miles, towards the Chinese frontier. It is a significant fact that four out of the world's five highest summits* occur in the immediate neighbourhood of this bend in the axis of the range.

Mt. Everest, or rather its giant satellite Makalu, overlooking the gorge of the Arun river, provides an example of the curious law which has often been noted in the Himalaya, regarding the occurrence of high peaks in close association with deep gorges. The Arun river is an important tributary of the Kosi, itself a feeder of the Ganges; it carries the drainage of the Kampa and Tingri plains southwards through the Himalaya range, yet, with an available length of 200 miles along the range out of which to choose its passage, it has elected to pierce its gorge (at a height of 7,500 feet) within 18 miles of the summit of Makalu (27,790 feet.)

* Everest, 29,002 ft.; Kangchenjunga, 28,150 ft.; Everest S. Peak (Lhotse) 27,890 ft.; Makalu, 27,790 ft.

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On a clear day, Everest is visible from the plains of northern India at a distance of over 100 miles. It may also be seen, at a slightly closer range, from the neighbourhood of the hill-station of Darjeeling; but, owing to its great distance, it appears a comparatively inconspicuous object, and has consequently never been deemed worthy of a name by the natives of India.* Among the Tibetans, the mountain is known by the name of "Chomo Longma" or "Chhama Lungmo"—a phrase which has been variously interpreted as: "the liberal-minded fairy," "the goddess-mother of the country," "the place of the female eagle," and "the mountain which is so high that a bird is blinded by flying over it!" Personally, I prefer the first of these renderings!

Up to the middle of the last century, Kangchenjunga was believed to hold the supreme place among the mountains of the world. The discovery of Everest as the world's highest summit was made by an Indian computer when working out the results of some observations taken by the Great Trigonometrical Survey of India three years previously. About the year 1850, the field-work of the principal triangulation of India had been extended northwards over the whole peninsula, and was being brought to a close by a series of long rays to numerous "intersected points" along the snowy ranges of the Himalaya. The computation of the results of these observations entailed several years of work in the survey offices at Dehra Dun, and the story is on record in the office archives of how one morning the excited Bengali assistant rushed into the room of his chief, waving a sheet of paper and exclaiming: "Sir, I have discovered the highest mountain in the world!" The height, as then deduced from the mean of six rays averaging 111 miles in length, came to the now familiar figure of 29,002 feet. As the result of subsequent additional observations, combined with an improved knowledge of the laws of terrestrial refraction and of the deflection of the plumb-line at the stations of observation, this figure is now believed to be too low by approximately 150 feet.

In the absence of any native Indian name, the Surveyor-General, Sir A. Waugh, decided to christen the mountain after his distinguished predecessor, Colonel Sir George Everest, under whose direction the triangulation had been carried out which resulted *inter alia* in the discovery of the mountain. Mt. Everest thus forms the only exception to the accepted rule forbidding the use of European proper names for Himalayan peaks. The title has now been so long firmly established throughout the English-speaking world as to preclude

* On the expedition of 1922, General Bruce's Gurkha orderlies usually referred to the mountain as "Himal chuli" which may be translated as "the rocky snow-peak," but this cannot be regarded as a proper name.

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the possibility of any change. It is noteworthy, however, that the name Mt. Everest has not hitherto been accepted by Continental geographers, who, relying on an erroneous observation made by the Schlagintweit brothers 75 years ago, still persist in calling the mountain Gaurisankar. Gaurisankar (called by the Tibetans "Chomo Tshering") has long been known to be an entirely distinct mountain, 35 miles west of, and 5,560 feet lower than Everest. It is regrettable that the publishers of a modern standard British work such as the new *Times Survey Atlas* should see fit in the year 1920, to perpetuate this confusion by labelling the world's highest summit "Mt. Everest, or Gaurisankar."

For a period of 60 years after its discovery, access within 75 miles of Everest was barred by its position on the frontier between Tibet and the Native State of Nepal, both of which territories have for the last century and a half been normally closed to European travellers.* About the year 1912, however, consequent on the decline of Chinese influence in Tibet, an expedition to Mt. Everest through Tibetan territory first began to appear as a practical possibility. Major Rawling of the Somerset Light Infantry, a well-known traveller on the Tibetan borderland and in New Guinea, was planning an expedition of reconnaissance for the summer of 1915, to be followed by

* It is worthy of record that in the 17th and early 18th centuries, both Nepal and Tibet appear to have been freely open to European travel. In both countries, Capuchin and other mission stations maintained a precarious existence for many years. The earliest recorded European travellers in the neighbourhood of Mt. Everest are the German Jesuit, Johannes Grueber, and his Belgian companion Albert de Dorville, in 1661–62. Grueber, who occupied the position of mathematician to the Court of Peking, received a summons to Rome early in 1661. The sea route being closed owing to war with Holland, Grueber was instructed to discover a route to Europe overland. Travelling by way of Sining Fu and Lhasa, he thence proceeded south-west to Katmandu and India *via* Kuti (Nyenam) and the valley of the Bhotia Kosi river—finally reaching Italy through Makran, Persia and Asia Minor. Grueber made sketches of his route, and also carried an astrolabe with which he took occasional observations for latitude. His results exhibit a general mean error of about half a degree.

During the first half of the 18th century there appears to have been frequent traffic across the Himalayan passes between the Capuchin mission then existing at Katmandu and the various branch establishments in southern Tibet. The only journey, however, of which a record exists is that of Cassiano Beligatti de Macerata, one of a party of ten Capuchin monks returning from Europe to re-establish the mission at Lhasa. Leaving Patna in December, 1739, the party remained at Katmandu (then only a provincial town) until after the rainy season of 1740. Their route led through Kuti and the Tingri plain to Sakya and Gyantse; Beligatti's description of the country and people might well have been written to-day.

It was while the Capuchin missions were still in existence, between

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a serious climbing effort the next year. The war, however, intervened, in the course of which Rawling was killed as a Brigadier-General in France, and the project was, of course, temporarily abandoned.

Interest in Mt. Everest revived as soon as the war was over. During the summer of 1920, Lt.-Col. Howard Bury visited India at his own expense in order to enlist the sympathy of the Government of India towards an expedition. He also visited Darjeeling, and reconnoitred the routes through Sikkim as far as the Tibetan frontier. At the same time Dr. A. M. Kellas and myself undertook some investigations into the use and effects of oxygen at high altitudes on Mt. Kamet, in the Garhwal Himalaya.*

THE EXPEDITION OF 1921.

As the result of Howard Bury's mission, Mr. (now Sir C. A.) Bell, the Political Officer in Sikkim, who happened to be in Lhasa at the time, was instructed to ask the Dalai Lama for permission for a small party to enter Tibet for the purpose of exploring and climbing Mt. Everest. Mr. Bell being on the most friendly terms with His Holiness, the necessary permission was granted towards the close of the year, 1920, and thus the one great obstacle in the way of an approach to Mt. Everest was at last removed. The Mt. Everest Committee was at once formed, consisting of three representatives each from the Royal Geographical Society and the Alpine Club, under the able and enthusiastic chairmanship of Sir F. E. Younghusband. Funds were raised by means of initial grants from the two societies supplemented by public subscriptions, and the organization and equipment of an expedition were hastily put in hand.

The Mt. Everest Committee rightly decided that the whole of the first season must be devoted to a thorough reconnaissance of the mountain with a view to finding not only a feasible route to the summit, but what was without doubt the *most* feasible route. This was considered ample work for the first year's expedition, while the season of 1922 would be devoted to an all-out effort to reach the

the years, 1723 and 1736, that the adventurous Dutchman, Samuel Van de Putte, visited Tibet in the course of a remarkable 20 years' tour from Aleppo to Peking. He appears to have been an excellent Tibetan scholar as well as a skilled and competent observer, but on his death (in Batavia on his way home in 1745), his papers were all burnt under the terms of his will. His sketch map of southern Tibet, which is, however, still extant, gives the positions of Kuti, Tingri and the Phung Chu.

From the final closing of the missions in 1745, there is no further record of travel in this portion of southern Tibet until the period of the Survey of India trained native explorers, a century and a quarter later.

*An account of this trip appeared in the *R.E. Journal* for April, 1921.

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summit along such route as the first year's reconnaissance should indicate as the best.

The members selected to form the first season's party were as follows :—

Lt.-Col. C. K. Howard-Bury, D.S.O., Leader of the Expedition.
Dr. A. M. Kellas
C. Raeburn
G. H. L. Mallory
G. H. Bullock
} Mountaineers.
A. F. R. Wollaston, Doctor and Naturalist.

On arrival in Darjeeling early in May, the party was joined by Dr. A. M. Heron, of the Geological Survey of India, and by a small survey detachment consisting of the writer and Bt. Major E. O. Wheeler, M.C., together with three Indian surveyors. Wheeler, who is a member of the British and Canadian Alpine Clubs, had been entrusted with the task of making a photographic survey of the immediate environs of the mountain on the 1-inch scale, while the remainder of the detachment were to be employed on a general ¼-inch plane-table survey of the whole area covered by the expedition.

The main body of the expedition, together with 100 mule-loads of stores, left Darjeeling in two parties on 18th and 19th May. A week's marching brought the party across the Sikkim frontier *via* the Jelep pass into the Chumbi valley of Tibet. At the head of the Chumbi valley is the village and *dzong* (fort) of Phari, the residence of the *dzongpen* or governor of the district. Phari is a bleak, dirty village, situated at a height of 14,300 feet above sea-level, and well above the tree-line. Transport arrangements here necessitated a halt of some days while the *dzongpen* was collecting fresh pack animals and supplies for the six days' journey to his colleague at Kampa, which was reached on the 5th June. Here I joined the expedition, having travelled from Darjeeling *via* Thango and the Serpo pass in order to superintend the revision of the map of northern Sikkim.

The arrival of the expedition at Kampa was saddened by the death of Dr. Kellas, from heart-failure consequent on severe gastritis. He had been unwell from the start, but with characteristic determination had refused to give in or to turn back. He was buried the following day on a spur below the *dzong*, in sight of the three great peaks of Chomiomo, Pauhunri, and Kangchenjau, which he alone had climbed. Raeburn, who was also unwell, was at this point compelled to return temporarily to Sikkim under Dr. Wollaston's care.

Resuming our march on 8th June, Tengkye *dzong* was reached in two stages, and here we first came into unsurveyed country. At Kampa I had started a chain of triangulation based on Colonel

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Ryder's old stations made at the time of the Lhasa Mission in 1903-4. I realized, however, that with daily marches averaging 15 to 20 miles it would no longer be possible to keep this up, and that it was necessary to decide at once whether to delay the surveyors sufficiently long to enable a triangulation to be carried forward, or, alternatively, to allow them to keep pace with the expedition while merely utilizing the previously existing triangulated points, of which a fair number were visible. In view of the obvious signs of a rapidly approaching monsoon, I decided in favour of the latter alternative.

From Tengkye we marched in six stages to the next *dzong*, Shekar—crossing the broad, sandy bed of the Shiling river a mile above its junction with the Phung Chu. Owing to the prevalence of rinderpest in the Phung valley, the transport yaks and bullocks provided by the *dzongpen* of Tengkye had to be replaced by donkeys for the last two marches before reaching Shekar.

The Phung river is remarkable for the amount of mud which it carries in suspension; below Shekar it flows through a wide, open valley with occasional stretches of fertile marsh-land, and scattered clumps of a stunted species of *salix*, resembling sea-buckthorn, known in Tibetan as "lamdse." Flowering clematis is common, and a sweet-smelling valerian or candytuft—the latter is said by the Tibetans to be very poisonous, and is carefully avoided by cattle.

The town of Shekar is situated 5 miles north of the Phung Chu, on the edge of a level plain containing numerous irrigated fertile barley-fields, and scattered hamlets. The large monastery of Shekar Chote is finely situated on a commanding hill behind the town to which it gives its name—Shekar being an abbreviation of "Shel karpo" (white glass), in allusion to the numerous windows and conspicuous white-washed walls of the monastery, which glisten in the morning sun.

Resuming our journey up the Phung valley, Tingri was reached in two long marches. The village is built on the slopes of a low, isolated hill in the middle of an extensive alluvial plain. The hill is crowned by the remains of an old Chinese fort, now abandoned; just below is the former residence of the Chinese commandant—a building now used as a "circuit house" for Tibetan officials when on tour. This was destined to be the headquarters of the expedition for the next six weeks, and formed a convenient centre for various scientific excursions into the surrounding districts; a dark-room was installed in which were developed the photographs taken by the several members of the expedition.

After a few busy days spent in sorting and arranging stores, Howard Bury and Heron started on a hasty reconnaissance of the tracts of country known as Pharuk and Kharta, lying to the north and east of Mt. Everest, with the object of selecting a suitable site for the next headquarters when a further move should become neces-

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sary. Mallory and Bullock set off to examine the north-west approaches of Everest, and to train the coolies in ice, snow and rock technique. Wheeler commenced his photo-survey in the neighbourhood of Kyetrak, two marches to the south. I spent a week with one of the surveyors exploring and mapping the western headwaters of the Phung Chu.

Early in July in response to an invitation from the *dzongpen* of Nyenam, Wollaston and I, with Surveyor Gujjar Singh and an interpreter, started on a visit to the district of Nyenam which lies four marches to the south-west of Tingri. Our first camp was at Lungkor, a small village on the western edge of the Tingri plain. Crossing the Thung La (17,980 feet) in a driving snow-storm, a long march of 22 miles brought us next day to the bleak village of Tulung, in the upper valley of the Bhotia Kosi river. Two days later we reached Nyenam, a large and very insanitary village which is known under the name of Kuti by the Nepalese, who constitute the majority of its inhabitants. These Nepalese traders (*newars*) have their own Hindu temple in the village ; there is also a Nepalese magistrate, having summary powers of jurisdiction over Nepalese subjects.

I spent three days in exploring the neighbourhood of Nyenam, while Wollaston was engaged in his botanical and zoological pursuits. Below Nyenam the river enters a very narrow gorge, while pines and other forest trees begin to appear ; the road, which here becomes impassable for animals, crosses the river four times in eight miles before reaching the village of Choksum, but owing to the vile state of the weather which rendered even the roughest attempts at surveying impossible, I abandoned any idea of further progress down the valley.

Returning up the valley to Trashigang, we next followed a rough track leading in a south-easterly direction over the Lapche range to the village of the same name in the valley of the Kang Chu. We were unable to reach the village by dusk, and spent a somewhat miserable night camping on boulders in drenching rain at 14,600 ft., with no fuel except a few green twigs of dwarf rhododendron.

Lapche is sacred as the home and birthplace of Mila Repa, a wandering lama and saint who lived in southern Tibet in the eleventh century, and whose collections of songs and parables are still among the most popular books in the country. His hermit-cell still remains under a rock on the hillside, and his memory is preserved by an ancient temple, the resort of numerous pilgrims, alongside which we pitched our tents.

From Lapche we crossed the Kangchen pass into the Rongshar valley. As we descended the hill into Trintang village, the clouds lifted momentarily, disclosing an amazing view of the superb summit of Gaurisankar towering magnificently above us just across the valley. Owing to the sacred nature of the Rongshar valley, the

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slaughtering of animals is forbidden, and the large flocks and herds are only kept for sale in Tingri and Nepal. We were only able to buy a sheep on promising not to kill it until after quitting the valley.

On 27th July we marched 20 miles up the Rongshar valley to the village of Tasam (Takpa-Santsam = "limit of birchtrees") which, as its name implies, is situated at the extreme upper limit of the forest zone. The headman of Tasam was too drunk on the evening of our arrival to send out the necessary messages summoning the village baggage yaks from their grazing grounds. In consequence, our baggage next day only got started at 11 a.m., and we were compelled to pitch our tents at a grazing camp after covering only nine miles. The weather showed signs of improvement in proportion as we receded from the Himalayan gorges, but dense banks of cloud still obscured all the hill-tops. An easy march over the Phuse pass brought us on 29th July to the bleak village of Kyetrak at the extreme southern edge of the Tingri plain. Four days later we rejoined the expedition headquarters which Col. Bury had just transferred to Kharta, in the lower valley of the Phung Chu or Arun river.

It is now time to turn to the doings of the mountaineers. Leaving Tingri on 23rd June, Mallory and Bullock—the only two now left out of the four climbers from England—turned southwards into the unknown, to explore the western and northern fastnesses of Everest. Approach was soon found to be barred from the west and north-west by the great peaks of Cho Uyo and Gyachungkang, and the climbers turned their attention without further delay to the Rongbuk valley which drains the northern slopes of the mountain. The great Rongbuk glacier, terminating five miles above the village and monastery of that name, was at once seen to be divided, higher up, into at least two important branches—the western branch swinging round from the southern slopes of Gyachungkang, and the main or central branch ending in a great coombe or cirque under the north face of Everest itself. These two branches were explored in turn, in the face of the most adverse conditions of weather, due to the monsoon season which had now become firmly set in; enough of the landscape was, however, visible to establish the following facts:—(1) That the key to the mountain appeared to be an important saddle—subsequently known as the North Col (Chang La), 23,000 ft.—situated at the head of the main Rongbuk glacier, about 1¾ miles north of the summit of Everest; and (2) that only in the very last resort could the main Rongbuk glacier be made use of as a means of access to this North Col, and that an examination of its further (*i.e.*, eastern) flank was the next essential requirement. Towards the end of July, therefore, the two climbers struck their tents, turned their backs on the Rongbuk valley, and hastened to rejoin Howard Bury in the newly-established base camp at Teng on the bank of the Arun river in the district of Kharta.

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A broad glacier stream, the Kharta Chu, coming down from the west, and therefore, as it appeared, from Everest, joins the Arun river at Kharta. To follow this stream to its source seemed the next obvious plan, after a few days for rest and re-organization in the pleasant surroundings of Kharta.

Accompanied by a local Tibetan guide, Mallory and Bullock accordingly set out once again on 2nd August; following the upward course of the Kharta stream, past scattered hamlets and waving fields of barley, they camped for the night at a spot where a small tributary joined the main stream from the south. To their surprise the guide led them next day up this side stream, over a pass which he called Langma La, 4,000 ft. above their camp of the previous night. A long descent followed, leading them eventually, baffled and bewildered by continual cloud and mist, to the foot of an enormous glacier* draining in a south-easterly direction. Not until the third day did the clouds lift sufficiently to disclose for a few moments the gigantic precipices of Makalu towering above them to the south.

Altogether, a week was spent in exploring this Karma valley—a valley which is directly overlooked by three out of the five highest peaks in the world. At the broad head of the Karma valley were the two summits of Everest, and Everest South Peak (Lhotse); 10,000 feet below these lay a great basin of tumbled ice, fed by frozen tributaries pouring down between the almost perpendicular buttresses which support the mountain faces in this enormous cirque. Obviously no route to the summit was to be found here, but on climbing a peak on the northern side of the valley, the explorers fancied they recognized in the distance, away to the north-west and almost masked by cloud and intervening ridges, the outline of the elusive North Col, situated apparently beyond the head of the Kharta valley. Retracing their steps over the Langma pass, they succeeded on 18th August in reaching the Col at the head of the Kharta valley which we subsequently christened Hlakpa La, or Windy Gap (22,200 ft.). I was able to join the climbers on this last piece of reconnaissance. Looking westward from the summit of the Windy Gap, the lower slopes of Everest were dimly discernible through the clouds away on our left about 2½ miles distant; directly in front of us, at a slightly greater distance, were the eastern slopes of what we judged to be the North Col; everything above our own level was concealed in a dense bank of cloud. Between us and the North Col, we looked down on a broad, smooth bay of ice and snow 1,000 feet below, draining towards the north—whether this represented a hitherto unsuspected eastern branch of the Rongbuk glacier, or whether it drained into the Rephu branch of the Dzakar stream, we were at the moment unable

* The Kangshung glacier.

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to ascertain. Anyway, a possible route to the North Col had been discovered and we were now justified in returning to Kharta for ten days' rest and re-organization, prior to a final assault in which all were to take part as soon as the monsoon should begin to abate.

Howard Bury and Wollaston were already at the base, Heron arrived the following day, followed shortly afterwards by Wheeler, whose photographic survey of the Rongbuk glaciers had been greatly delayed by the appalling weather. Wheeler was able to confirm the important fact that the glacier* on to which we had looked down from the Hlakpa La, drained into the Rongbuk valley, through a narrow gorge which had been overlooked by the mountaineers in the mists and cloud during their first reconnaissance of the Rongbuk glaciers. It was now, however, too late to transfer our line of communications back again to the Rongbuk valley; for this season we were committed to carrying out our assault on the North Col *via* the Windy Gap.

After three weeks of tedious waiting in the upper Kharta valley, the weather improved sufficiently by 22nd September to enable us to establish a camp of six Europeans and 18 coolies on the summit of the Windy Gap. Mallory, Bullock and Wheeler, with ten selected porters, next day pushed forward a light camp to the foot of the North Col. On the 24th they succeeded in reaching the summit of the Col (22,990 feet) in the face of a terrific blizzard which rendered further progress impossible. Beyond the Col, an easy succession of rock and snow slopes could be seen leading to the north-east shoulder of Everest (27,390 feet.)

This closed the season of 1921. The results of the season's work may be briefly summarized as follows :—

(1) The north, east and west flanks of the mountain had been thoroughly explored, and a practicable route of ascent discovered, the key to which was the North Col, which had actually been reached *via* the Kharta valley and Windy Gap, but which would, doubtless, be more easily accessible *via* the East Rongbuk glacier. From the time when we first viewed the mountain early in June until the end of the season it had presented an unbroken white surface of ice and snow; rock was scarcely anywhere visible.

(2) High climbing between 15th June and 15th September had been proved an impossibility owing to the prevalence of monsoon conditions, while from the middle of September the monsoon was found to be succeeded by a series of terrific equinoctial gales from the north. The only hopeful season for climbing at extreme altitudes in the Himalaya thus appeared to be the months of May and early June.

* Since known as the East Rongbuk glacier.

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(3) 12,000 square miles of new territory were surveyed on the ½-inch scale, and 4,000 square miles of old ½-inch survey were revised. 600 square miles of the immediate environs of Mt. Everest were mapped photographically on the 1-inch scale.

(4) The geology and natural history of the area were worked out with considerable thoroughness. Interesting collections were made of mammals, birds, butterflies and plants, all of which were found to include new specimens.

The Expedition of 1922.

Howard Bury having become a candidate for election to Parliament, the charge of the 1922 expedition was given to Brig.-General the Hon. C. G. Bruce, C.B., M.V.O. (now President of the Alpine Club), with Colonel E. L. Strutt, C.B.E., D.S.O., as his second-in-command. The remaining members selected in England were :—

G. H. L. Mallory
T. H. Somervell
A. W. Wakefield
G. I. Finch
Major E. F. Norton
} Climbers.

Dr. T. G. Longstaff, Doctor and Naturalist.
J. B. L. Noel, Photo and Cinema Expert.

The party were joined in India by C. G. Crawford of the Indian Civil Service and the writer, together with Captains Morris and G. Bruce, of the Indian Army.

An important addition to this year's equipment was a number of sets of oxygen apparatus, under Finch's special charge. Each set comprised a light carrier supported on one's back by a system of web belts and straps, and carrying four cylinders of compressed gas, which was delivered to the face mask by a system of flexible piping with a pressure-reducing valve and adjustable flowmeter. The weight of the apparatus was about 35 pounds, and each cylinder was reckoned to last about 1¼ hours at a normal flow of three litres per minute. Empty cylinders could be disconnected and replaced as required.

Leaving Darjeeling on 26th March, the expedition followed the route of 1921, in bitter weather, as far as Shekar, whence they turned southward over the Pang La pass to Tashidzom and Chobuk. The base camp was pitched at a height of 16,500 feet in the Rongbuk valley, just below the snout of the glacier and twelve miles distant in a direct line from the summit of Everest. In contrast to our experience of the previous year, the northern slopes of the mountain now, before the onset of the monsoon, proved, to our joy and surprise,

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to be almost devoid of snow and ice, displaying a not too formidable-looking surface of black slabby rock.

The base camp was established by the end of April, and the next three weeks were occupied in reconnoitring the East Rongbuk glacier (the only portion of the route not fully explored in 1921), laying out the advanced camps, and stocking them with supplies and equipment. By 20th May, camps had been established as follows :—

No. 1 Camp—18,000 feet, just above junction of E. Rongbuk valley with main Rongbuk valley.
,, 2 ,, 19,000 feet, half way up E. Rongbuk glacier, on moraine.
,, 3 ,, 21,000 feet, at foot of North Col, on moraine.
,, 4 ,, 23,000 feet, at summit of North Col, on snow.

The time now appeared ripe for a serious attack on the mountain, so while Finch was still busy assembling his gas apparatus, Mallory, Somervell, Norton and myself with ten porters, left Camp III for the North Col (where, as just mentioned, we had already established a camp). Sleeping at the North Col on 20th May, we continued next morning the ascent of the northern face of the mountain over fairly easy going until the onset of a blizzard at midday compelled us hurriedly to camp at 25,000 feet (Camp V), and send the coolies back to the North Col. The hillside was composed of flat slabs of rock of varying sizes, the strata having an outward (northerly) dip ; and it was a matter of some difficulty to scarp out with our ice axes a couple of level terraces sufficient to hold our two small mountain tents. We finally succeeded after a fashion, and spent a tolerably comfortable night, the temperature dropping to minus 20° F.

Next day broke fine, with a powdering of freshly fallen snow on the ground, and after hastily warming up a light breakfast over the spirit stove we were roped up ready to start by 7.30 a.m. The first hundred yards sufficed to assure me that for some reason I had not that day the pace of my three companions, so rather than keep them back, I felt my duty was to unrope, leaving them to carry out their climb untrammelled. In the result, while I remained smoking my pipe in camp, they succeeded in attaining a height of 26,850 feet, just below the north-east shoulder of Everest*, before the lateness of the hour compelled them to turn back. They had reached a point within one mile of the summit, and there appeared to be no serious obstacle in this last remaining lap—only, it was more than could be accomplished in one day from the camp at 25,000 feet. One more intervening camp would be necessary, at about 27,000 feet, and this we had not the immediate means of achieving.

* The N.E. shoulder is marked 27,390 feet on the sketch-map.

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It was about 4 p.m. when Mallory and his two companions rejoined me at Camp V, and after hastily melting down sufficient ice to give us each a mouthful of drink, we decided to make at once for the North Col. Instead of benefiting by my day of idleness in camp, my physical incapacity had now become almost complete; and, leaning on my companions' arms, I could scarcely find the energy to descend the easy slopes up which I had gaily led on the rope less than thirty-six hours previously. It was 10 or 11 p.m. and pitch dark before we finally reached the shelter of the North Col camp, too tired even to hunt out some supper.

Next morning, as we wearily made our way down towards Camp III, we met Finch, Geoffrey Bruce and a Gurkha N.C.O., Tejbir, starting on their high climb, with oxygen masks already adjusted and in use. They were being accompanied for the first few miles by Dr. Wakefield who carried a thermos flask filled with hot tea and brandy which remains one of the happiest recollections of my life. Shortly afterwards, on nearing Camp III, we came to the first spot at which a little trickle of water had been melted by the midday sun. Lying prone, I lapped and lapped until I had absorbed, perhaps, a quart of this icy beverage. Instantaneously my strength returned, and I then realized that my whole trouble had been simply due to the impossibility of obtaining sufficient liquid at the high altitudes. All four of us proved to have been more or less frost-bitten during our descent to the North Col the previous night; in the case of Mallory and Somervell the damage was limited to a few skin blisters on the extremities. Norton's beauty has been permanently impaired by the loss of the top of one of his ears, and I had to undergo, five months afterwards, the amputation of the top joint of three fingers of my right hand.

Finch, G. Bruce and Tejbir, with their string of coolies, after sleeping at the North Col, carried a camp to 25,500 feet, at which point the onset of a blizzard compelled them as it had us, to pitch their tent and send back their coolies. For thirty-six hours the storm raged with unremitting violence; the ceaseless flapping of the little tent was afterwards compared to the noise of a machine-gun in one's ear, while the three occupants dared not stir outside for a moment lest the whole frail outfit should be carried bodily away by the force of the wind. On the third day, still supported by their remaining supply of oxygen, they reached a height of 27,250 feet before being compelled to return—being then about half a mile in horizontal distance from the summit of the mountain.

By the end of May, all the climbers were back at the base camp, and all of us were to a greater or less degree *hors de combat* as the result of our experiences. A universal symptom was the loss of one or two stone in weight during our sojourn above the snow line, combined with a strong feeling of disinclination for further exertion.

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Early in June, Mallory, Somervell and Crawford gallantly organized a third assault, but the monsoon had meanwhile set in and the mountain sides had become dangerous. An unfortunate avalanche occurred on the steep ascent to the North Col, carrying away one whole rope of coolies, all seven of whom were killed instantaneously. This disaster closed the climbing season of 1922.

The results of the 1922 expedition were :—

(1) Heights of 27,250 feet and 26,850 feet were attained, with and without oxygen respectively, and it was ascertained that no serious physical obstacles exist between the highest points reached and the final cliff of 100 or 200 feet which marks the actual summit. Camps were made at 25,500 feet and 25,000 feet, but from these heights it was found impossible to reach the summit and return in one day.

(2) The months of May and early June (before the arrival of the monsoon) were definitely proved to be the only possible season of the year for the climb—thus confirming the deductions made from the experiences of 1921. Further, at this time of year the whole northern face of the mountain was found to consist of bare rock.

(3) Oxygen was tried for the first time in actual use at extreme heights, and gave proof of its value.

(4) Further collections were made of the natural history and geology of the regions traversed.

CONCLUSION.

The question is sometimes asked : why steps have not been taken to explore the southern (Nepal) faces of Mt. Everest before definitely accepting the North Col route as being the best : and, in any case, why do successive expeditions follow the long roundabout road to the base camp through the Chumbi valley and the plains of Tibet, instead of taking a direct route northwards from the plains of India through Nepal, and thus reducing the distance of the outward and homeward marches from 350 miles to one-third of that distance. These points demand a few observations. Firstly, the Nepal Government do not favour European travel in their territory, and, although their attitude towards the enterprise may be inferred from their generous and spontaneous contribution of 3,000 rupees (£200) towards the funds of the first year's expedition, yet it is uncertain whether or not they would give the necessary permission to traverse their country if such were asked for.

More cogent is the consideration that the routes leading northwards through Nepal are known to be mere coolie tracks swarming with leeches during the monsoon, and where any form of pack transport is an impossibility ; whereas in Tibet, and more particularly on the

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Sikkim-Chumbi Valley trade route, unlimited yak and mule transport is obtainable at cheap rates of hire.

Thirdly, arguing from the analogy of other known portions of the Himalaya, it may be stated with some confidence that the unknown southern slopes of Everest, exposed as they are to the full brunt of the monsoon precipitation, will be found far more deeply eroded, rugged and inaccessible than those on the northern face of the mountain. Further, the summer snow line on the sheltered northern slopes of the Himalaya is roughly 2,000 feet higher than that on the south.* Mention has already been made of the fact that the whole northern face of Everest was found to consist of almost bare rock in May, 1922. The reflected glare, always an important consideration at extreme altitudes, is also less on a northern than on a south-facing slope.

The next attempt on Mt. Everest is to be made in 1924. The third expedition will probably be a climbing affair pure and simple, but among the scientific problems whose solution is still desirable it must suffice to mention that the whole southern slopes of the mountain await an opportunity for survey, while a small area of country still requires elucidation at the head of the West Rongbuk glacier; further research is also desirable into the glaciology of the area (advance and retreat of glaciers), and into the problems of mountain physiology, with particular reference to the phenomena of acclimatization to altitude.

A very desirable addition to the next expedition would be the presence of a competent artist who might portray in oil or water colours a few of the many striking and gorgeous effects of sun, snow, cloud and rock which even the most efficient camera or cinema in the world cannot wholly reproduce.

A fifth high camp will be necessary somewhere about 27,000 feet. In 1922, it was found possible to camp and sleep in comparative comfort (barring blizzards) at 25,000 feet, where the barometric pressure is 10 inches; there should not be any further appreciable discomfort in camping at 27,000 feet, where the barometric pressure has only dropped another half-inch. The real difficulty is one of organization, and of the carrying capacity of human beings at these extreme altitudes.

Another great difficulty lies in the incalculable and uncertain nature of the weather from day to day, and it is here that the importance of oxygen comes in. Starting from No. III Camp, without oxygen, it would take three days to establish a camp at 27,000 feet; one day would then be required to reach the summit, and two days for the return to Camp III. Total six days. The

* Approximately 20,000 instead of 18,000 feet in the latitude of Everest.

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use of oxygen may, however, enable a party to accomplish in three days what would otherwise take six, and three days is possibly the longest interval which may ever occur between successive blizzards. The problem of establishing a depôt of spare oxygen cylinders at a height of 27,000 feet is, however, one of immense difficulty.

One hopeful element in the problem, on which these notes may be fittingly brought to a close, is the wonderful keenness and endurance displayed by the coolie porters of the expedition, to whom is due a very large measure of such success as has hitherto been attained. These hardy hillmen—known in their own language as *Sharpas* (or "Easterners")—born and bred under the shadow of Everest itself, showed a spirit which was beyond all praise. On the return to Darjeeling, after the death of their seven comrades, every single remaining man asked to have his name registered as a volunteer for the next expedition. With such splendid and willing assistance on the side of the attackers, it will, indeed, be a matter of surprise if Mt. Everest remains much longer unconquered.

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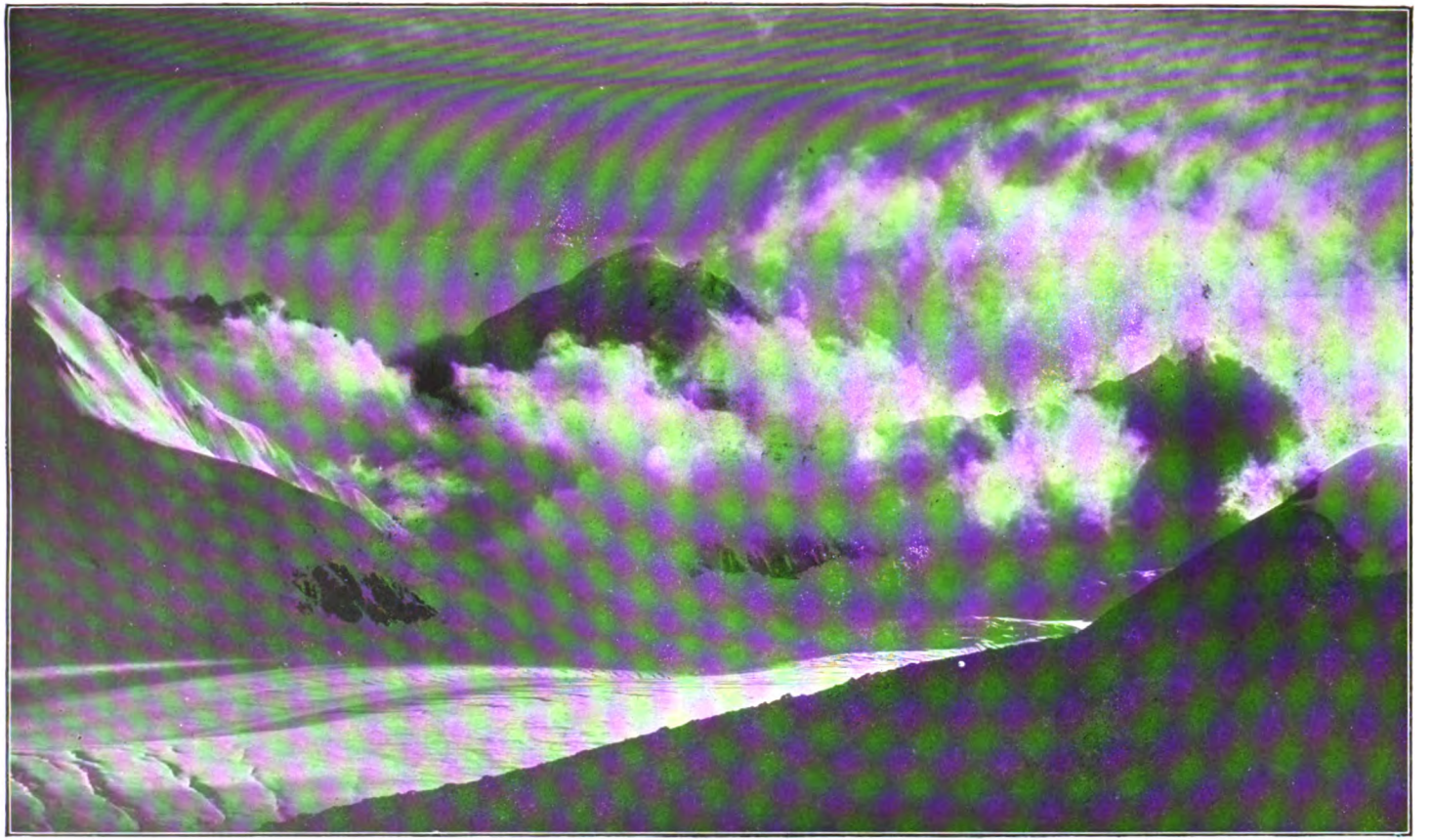

MOUNT EVEREST AT SUNSET, from 20,000 ft. Camp, Kharta Valley.

(Reproduced by permission of the Royal Geographical Society, from a photograph by Mr. A. F. R. Wollaston).

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SKETCH-MAP OF MT. EVEREST AND THE RONGBUK GLACIERS.

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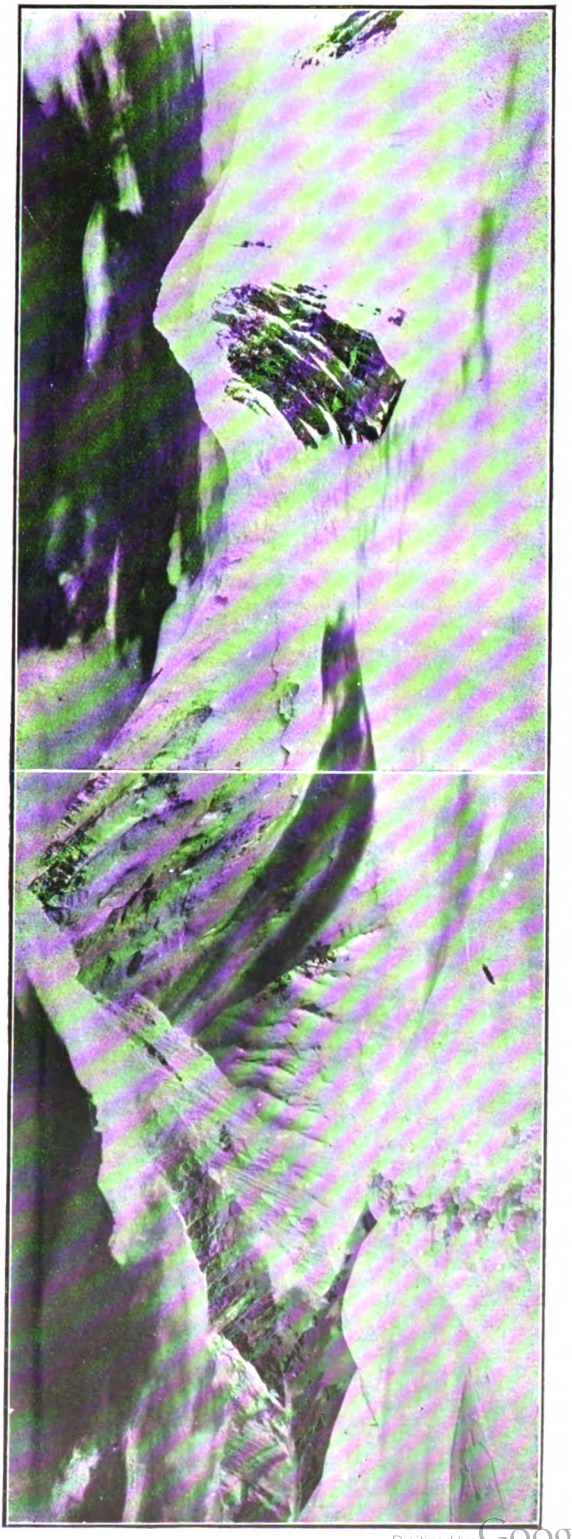

MOUNT EVEREST.

North Col and North Peak, from Hlakpa La.

Survey photograph by Major E. O. WHEELER, M.C.

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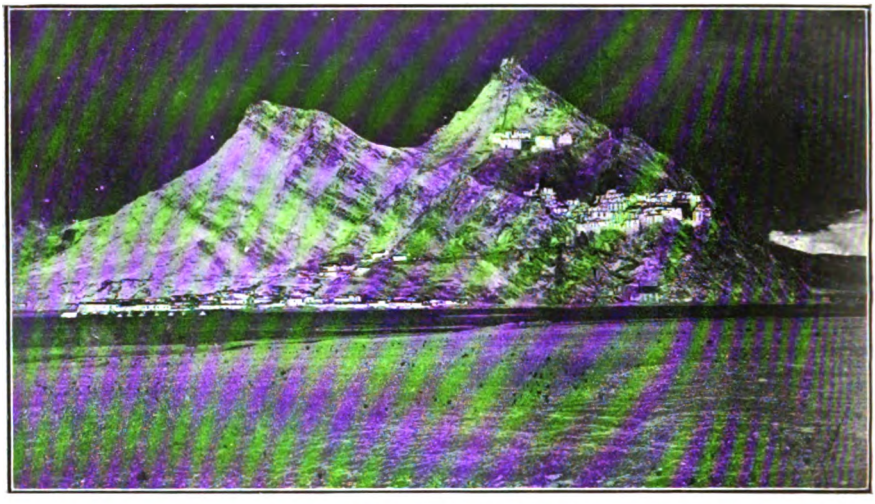
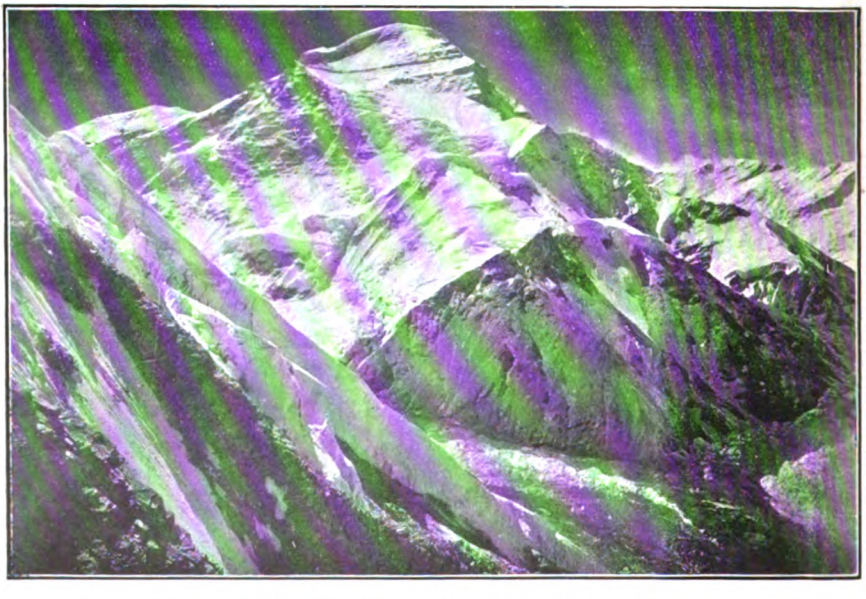


Shekar Village and Monastery.



Cho-Oyu from above Kyetrak.

Photographs by Major E. O. WHEELER, M.C.

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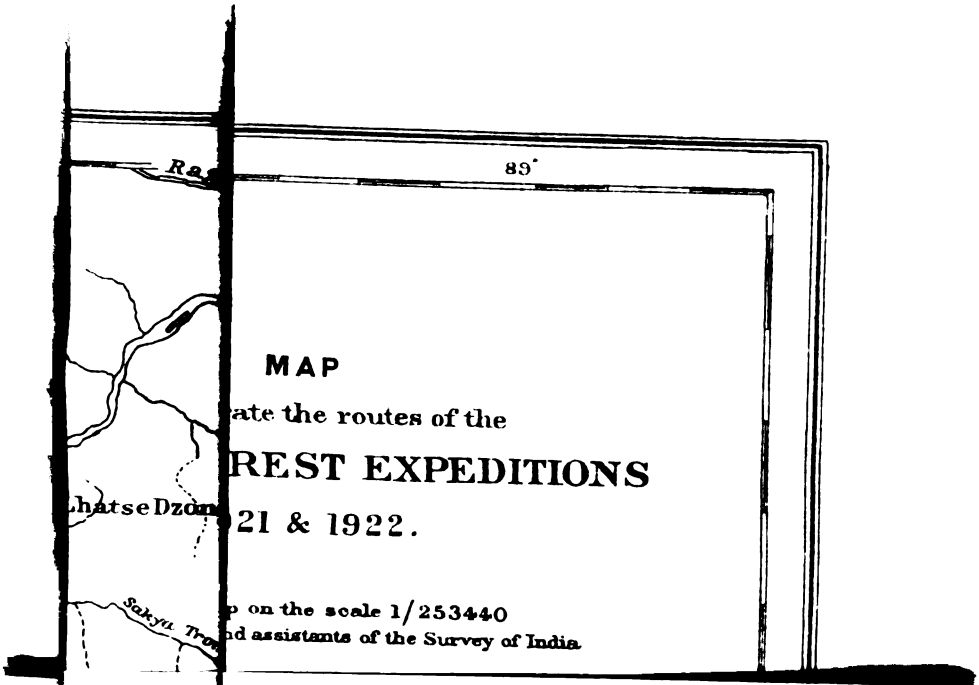

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SHAFT SINKING BY REFRIGERATION.

By LIEUT. P. J. AHERN, R.E.

THE effective sinking of a shaft through water-bearing strata, containing, as is usual in this country, loose quicksands, is often a matter of considerable difficulty. One of the most convenient ways of doing it, and one which was performed with conspicuous success as far back as 1885, by Captain Lindmark, of the Swedish Royal Engineers, in the construction of a tunnel at Stockholm, is to refrigerate the circumference of the shaft, and thus keep out the water, by maintaining a hard frozen shell round the portion which is being excavated.

Until recently, and especially in this country, progress in this system of shaft sinking has been slow, due primarily to the high cost of its operation, and to the effective rivalry of the cementation processes. In certain extreme cases, however, it is becoming increasingly employed in Germany and in Belgium, and, within the last few years, two important sinkings by this system have been carried out in this country, at Washington and Dawdon collieries, near Seaham harbour, Durham.

The principle of the process consists in freezing the ground, for a sufficient distance round the bore of the shaft, into an ice retaining-wall, capable of withstanding the pressure exerted by the unfrozen part, and so enabling treacherous layers to be worked in safety. Thus, the ice-wall consists of a hollow cylinder, completely enclosing the space in which the shaft is to be sunk, and at such a distance, that the process of sinking can be carried on without damage to it.

In practice, the wall is formed by sinking to the requisite depth a ring of vertical pipes, from 2 feet to 4 feet spacing, concentric to the proposed shaft, the number varying with the diameter of the cylinder to be formed.

The actual freezing apparatus consists of two concentric tubes through which cold brine circulates. (*Fig.* 1). The tubes are usually 1¼-in. and 4-in. diameter respectively, though for deep sinkings a 5-in. outer is sometimes used to give increased surface, and hence, increased cooling action, to the brine. The bottom end of the outer tube is sealed, while that of the inner tube, which can be easily removed for cleaning when necessary, is fitted with a strainer to prevent the passage of grit, etc. (*Fig.* 2). Where a considerable depth of solid strata is met which it is not desired to freeze, it is common practice to fix a third set of tubes between the inner and

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outer ones, for the depth that is not required to be frozen. (*Fig.* 3). The tubes of this third set are so connected to the outers that the return flow of the brine is between the inner and middle tubes, leaving an air-space between the middle and outer tubes, which acts, to a certain extent, as a heat insulator. The advantages claimed for this arrangement are that it lessens the work which the brine, and therefore the compressor, has to perform, and it avoids the exposure of the shaft work that is not to be frozen to the very low temperature

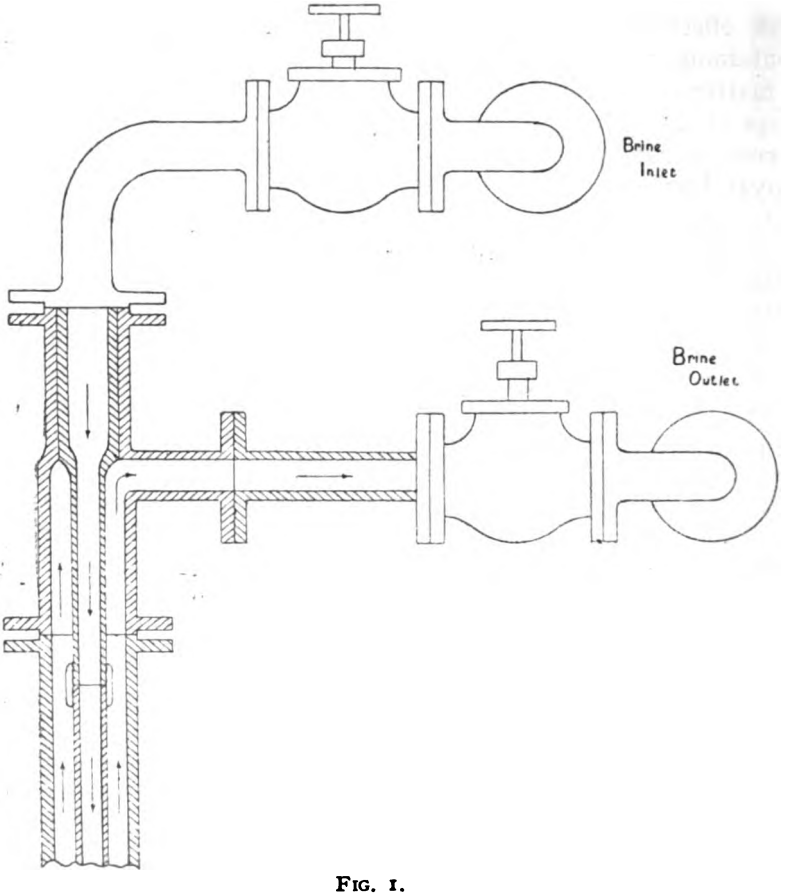

FIG. 1.

attained in the other strata. These advantages, however, are very much open to question. The convection currents set up in the air space rob it of a great deal of its insulative property, and the extra cost of the third set of pipes will often more than compensate for the increase of work required from the compressor.

Success in this method of shaft sinking is dependent upon two considerations. In the first place, the ice-wall must be carried down to a sound, substantial, substratum. A case of failure is reported in Saxony, where the freezing pipes were only carried down to a

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thick clay bed between two water-bearing strata, instead of to the stone stratum beneath the lower one. Secondly, the wells for the freezing pipes must be drilled absolutely vertically. This presents by far the greatest difficulty of the process, since the drill frequently encounters an oblique stratum of rock, which deflects it one way or the other, and the only remedy then is to fill the partially drilled hole and make another attempt.

When dealing with sand and softer strata, the wells may be bored, either with a sharp-edged tube and a sand pump, or alternatively, by capping the end of the larger tube and, forcing water out of a small hole in the end of another tube placed on one side of it, driving it through the soft stratum, by washing the sand before it.

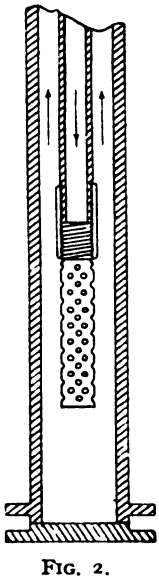

FIG. 2.

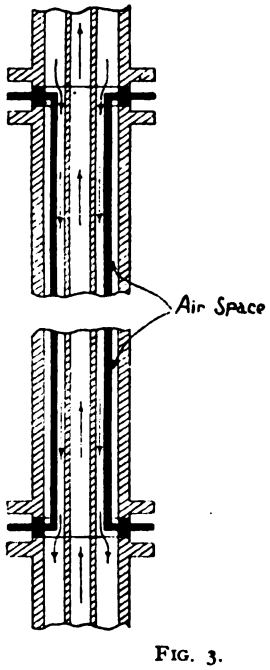

FIG. 3.

Calculations for this process offer no great difficulties, but most of the work is empirical. The ice cylinder when formed must be sufficiently strong to withstand the strains and stresses brought on it by the processes of sinking the shaft, as well as the outside forces due to ground and water movements, and the constant attrition, by the water surrounding the wall, due to convection currents set up in the water. In connection with this last effect, it will be seen that not only has the wall to be formed, but that it is imperative to maintain it at its required thickness, by continuing the brine circulation to such an extent, while the shaft is being completed, that the heat, which leaks into the wall from outside sources, is entirely absorbed.

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The requisite thickness of the ice-wall will vary according to the conditions present. It will necessarily be thicker with a deep sinking, than with a shallow one, and with a shaft of larger diameter, than with one of smaller diameter.

Owing to the large number of indeterminate variables that have to be dealt with—the varying water content, and the different degrees of freezing at various points in the wall, to mention only two—it is impossible to ascertain the tensile and compressive strengths of the material forming the wall; hence, to attempt to compute mathematically the minimum safe thickness of the wall, for any given set of conditions, would be useless. Certain figures have been found requisite in practice and these can be modified to suit requirements.

With 0° F. brine, the cylinder of ice formed usually extends about 3 feet inwards and 1 foot 6 inches outwards from the freezing-pipe ring. This wall will usually be found of sufficient strength for shafts up to 200 feet deep and 15 feet diameter. As however, modern tendency is to carry a brine temperature from −15° F. to −20° F., with the ice-wall at or near 0° F., when sea-water strata may be frozen, the ice-wall is proportionally thickened and strengthened, and the shaft figures given above may be increased to 350 feet deep and 30 feet diameter. For larger and deeper shafts a double ring of freezing-pipes should be employed.

Cooling will, of course, extend beyond the actual ice-wall itself for a distance of some 5 or 6 feet (*Fig.* 4). This cooled layer repre-

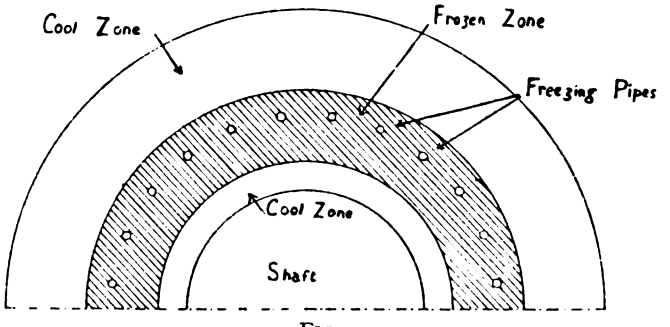

FIG. 4.

sents the heat insulator, and the heat carried across this area represents the heat which must be extracted by the brine to keep the wall frozen. In calculating the diameter of the freezing-pipe ring, from 1 ft. 6 in. to 2 ft. 6 in. of this cooling area should be allowed on the shaft side, so that the processes of sinking the shaft will not damage the ice-wall.

The formation of the wall is a very slow process, taking, in some cases, as long as three and four months. This is, however, all to the good, since ice that is formed slowly is the more durable, and the less likely to go "soft." The reason for this length of time is

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that the heat transmission to the brine from the earth surrounding the pipes, though quite high at first, falls rapidly away in value, until at the end of the freezing process it becomes nearly zero. Lorenz (Neuere Kühlmaschinen) suggests as an average value of the heat transmission, 85 B.Th. U.s per square foot of exposed pipe-surface per hour.

The calculation for the size of machine requisite for any given conditions is quite straightforward, and can be demonstrated far more clearly by the following example taken from an actually operated scheme, than by words.

Data :—	
Shaft measurements	16′ 0″×6′ 6″
Depth to sound stratum	28′
Average sp. gr. of ground	1·8
Average sp. ht. of solids (dry)	0·2
Average water content	30 lb./cub. ft.
Average ground temperature	50° F.
Data added from nature of problem :—	
Ice-line, inside, from pipe-line	3′ 0″
,, outside, ,, ,, ,,	1′ 6″
Cooling-line, inside, from ice-line	1′ 6″
,, outside, ,, ,,	5′ 0″
Depth of freeze	30′ 0″
Brine temperature	−15° F.
Minimum ice-wall temperature	0° F.
Average ice-wall temperature	16° F.
Average cooling-area temperature	41° F.
Freezing tubes, inner	1¼″
,, outer	4″
The pipe-line dimensions will be—	
[16′+2(3′+1′ 6″)]×[6′ 6″+2(3′+1′ 6″)]	25′ 0″×15′ 6″
Total length of pitch-line of pipes—	
2×25′+2×15′ 6″	81′ 0″
With tubes at 3′ centres, the number of tubes required—81÷3	27
Total length of tubing—	
27×30	810′
Surface of 4″ pipe exposed for cooling—	
$810\times\frac{3\cdot14\times4}{12}$	850 sq. ft.

A.—*Volume of ground to be frozen.*		cub. ft.
Volume enclosed by outer edge of ice-wall—		
28′×18′ 6″×30′	15540	
Less volume enclosed by inner edge of ice-wall—		
19′×9′ 6″×30′	5415	
		10125

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B.—*Volume of ground to be cooled.*

Volume enclosed by outer cooling-edge—
38′× 28′ 6″×30′ 32490

Less volume of frozen ground—
10125

Less volume of shaft—
16′×6′ 6″×30′ 3120

19245

	B.Th. U.s
A.—(1) To cool water from 50° F. to 32° F.— 10125×30×18	5,467,500
(2) To freeze water— 10125×30×144	43,740,000
(3) To cool ice to average temperature 16° F.— 10125×30×0·5×16	2,430,000
(4) To cool solids in the ice zone from 50° to 16° F.— 10125×62·5×1·8×0·2×34	7,745,625
B.—(1) To cool water to average temperature of 41° F.— 19245×30×9	5,196,250
(2) To cool solids to average temperature of 41° F.— 19245×62·5×1·8×0·2×9	3,897,125
Total heat to be extracted	68,476,500
Add about 33 per cent. to insure against losses	21,525,500
Actual working total heat—	90,000,000

Time to be taken to form wall—

$$\frac{90{,}000{,}000}{85\times850\times24}$$ 52 days

Capacity of plant in tons of refrigeration*—

$$\frac{90{,}000{,}000}{52\times288{,}000}$$ 6 tons

This is, however, the capacity required at an evaporative temperature of −15° F., *i.e.*, a suction pressure using an ammonia compressor of 5 lbs. per square inch gauge. Machines are normally rated at 27 lbs. per square inch suction-pressure and the capacity of any machine varies directly as the absolute pressure; hence a standard machine for this job would have to be capable of—

$$\frac{6\times42}{20}\text{tons}=12\cdot6 \text{ tons of refrigeration per day.}$$

It will easily be seen that a plant capable of forming an ice-wall will have ample capacity for maintaining it once formed, provided the outside conditions remain the same.

Further calculations for the size of condenser, cooling plant, brine pump, etc., are, of course, necessary. As examples of these may be found in any manual of refrigeration, no useful purpose would be served in inserting them here.

* 1 ton of refrigation=288,000 B. Th. U.s per day.

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*ENGINEER STORES IN THE GREAT WAR AND AFTER.**

UNDER pre-war conditions, technical equipment of R.E. units specified in " Mobilization Store " Tables, various tools, pontoon equipment, telegraph stores, those for printing, photographic and lithographical sections, with many others, were classed " Ordnance Stores." Their patterns were fixed and sealed, they were included in the " Vocabulary of Stores," and the duty of supplying them fell on the Royal Army Ordnance Corps, whose business it was to establish convenient depôts in England and in the field for first equipment and to meet wastage.

Building and engineering stores for peace-time works were included in items of Army estimates. They formed part of special contracts which, with some exceptions, were dealt with by the R.E. officer responsible for making the contract. The principal exceptions were electrical and mechanical plant and building stores for foreign stations, which were dealt with by the Director of Fortifications and Works through three sub-branches, viz. :—

F.W.4(a) *Electric Lights*, who designed, inspected and provided all articles of authorized R.E. equipment, and carried out special electrical duties.

F.W.4(b) *R.E. Committee*, who dealt with changes and improvements in equipment, and carried out trials and experiments.

F.W.4(c) *Iron Structures*, who carried out mechanical duties and arranged for contracts for the supply in bulk of building stores for foreign stations.

The placing of all War Office contracts, whether for engineering or otherwise, was the business of the Director of Army Contracts, a civil administrator with no technical engineering knowledge. Any changes found necessary after the contract had been placed entailed considerable delay in supply, so that procedure was slow and unsuited to the needs of an Army in the field.

The Ordnance Corps was fully occupied immediately war broke

* This article is a reproduction of two lectures delivered by Colonel S. L. Cra'ster, C.B., C.I.E., to the engineer students of the Bristol University. Through the courtesy of the Dean of the Faculty of Engineering, a lecture hall at the Merchant Venturers Technical College was placed at Colonel Cra'ster's disposal, and the lectures were illustrated by slides showing plant and machinery typical of the vast number of orders dealt with during the war.

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out and, finding itself unable to deal with demands from the front for articles not in the "vocabulary," the work of providing everything which was not authorized equipment fell on the Director of Fortifications and Works, and the present article deals in particular with F.W.4(c), the head of which was known as Inspector of Iron Structures (I.I.S.).

In August, 1914, the Army had no reserves of special engineering plant or machinery, nor were any contemplated, yet by the end of 1914 I.I.S., now on a war footing of 8 officers and 24 other ranks, were providing the multifarious demands for troops in the sphere of combat, for railways, roads, canals and docks in France, as well as for the Royal Flying Corps. Three of these officers were Civil Engineers and, as the war progressed, their numbers rapidly increased, and proved to the full the necessity for maintaining close touch between the Corps and the whole body of Civil Engineers. This close comradeship existed in all theatres of strife, and the interdependence of the Corps and the Civil Engineering profession was one of the great lessons of the war.

It was at once evident that peace procedure was too leisurely for war contracts and D.F.W. was authorized to handle his own, keeping the Director of Army contracts and the Finance branches of the War Office informed of action taken. At the end of a year the Director delegated his powers to Capt. R. Oakes, R.E., his Inspector of Iron Structures. The latter discussed demands with manufacturers on the telephone, decided what was suitable and immediately placed his orders. These, when the Director had concurred, were confirmed in writing.

Capt. Oakes' guiding principles were: (i) rapidity of supply; (ii) economy in price; (iii) efficiency of inspection; (iv) economy in cost of administration.

The continual extension of the world-war opened up fresh theatres in rapid succession, whilst varieties of climate and of natural resources and the kaleidoscope of military operations and events caused a flood of requisitions on the War Office. Many demands were novel, all were reported most urgent, and Capt. Oakes, in touch with his superiors, was obliged to differentiate. He therefore created a relative order of urgency in accordance with the special "inside" information he possessed, and brought to bear his invaluable practical experience, gained during the war in South Africa, and later as Locomotive Superintendent of a large South African Railway. Applying his four principles, and realizing that time in war is everything, he increased his staff of inspectors (from their peace footing of three military mechanists) by a few additional men, military and civil. He immediately ascertained the stocks of engineering and railway plant and machinery available in England, and during the first few weeks of the war he provided a reserve which

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was invaluable. Thus he utilized the breathing space which fell to the engineers; for at the outset no one could predict what would be the course of the campaign which opened in France and Flanders in 1914.

1914.—Oakes was a member of a War Office Committee which studied the requirements of *matériel* for the artillery and engineers for a great siege and accordingly provided for R.E. siege parks and workshops, for everything for 2 ft. 6 in. gauge railways, and for workshops and their equipment for the Royal Flying Corps. The siege did not occur, but the *matériel* was most useful for trench warfare.

Shortly after the war broke out, Oakes, already working at the highest pressure, was called on to act as Engineer Shipping Officer, and Qrmr. and Hon. Lieut. (later Lieut.-Colonel) A. N. Tucker, R.E., was selected as his representative at Southampton. Tucker and his small staff were indefatigable, but the port proved unsatisfactory, as it was so congested, and too far from Oakes' headquarters. On 1st January, 1915, Oakes' shipping organization was established at S.W. India Docks (Port of London) and steadily developed as need arose. Both as a store depôt and port of embarkation Abbey Mills and the Docks continually increased in importance and added to the efficiency of the Branch commonly known in the war as F.W.8.

Other ports, such as Liverpool, Newport, Southampton, Rochester, Grimsby and Immingham, were also freely made use of, as circumstances dictated, but the intense submarine campaign eventually forced I.I.S. to abandon the West coast ports, and Richborough was called on to take its share by means of barges and the train ferry.

To meet the difficulty of ensuring prompt shipment, a fleet of small vessels was allotted to Oakes, their numbers varying from 10 to 22, and by this means regular supplies were maintained between England and France. That this was appreciated by Field-Marshal Haig the following extract from his Dispatch of 25th December, 1917, will show :—

> " The supply of engineer stores and materials, now required in vast quantities, has throughout been efficiently maintained. . . ."

The scale of shipments is instructive, and may be studied in detail on the Graphs (*Plates* IV and V), but it is of interest to note, in passing, that, whilst 20,000 tons represented the monthly average of all military supplies of every kind delivered in South Africa during the last year of that war, for the last two years of the Great War the average monthly shipments of engineer stores (apart from anything else) was 40,000 tons, and this in face of difficulties of manufacture due to lack of raw materials of all kinds, to shortage and inferiority of labour employed, to congestion on the railways of the United Kingdom, and the ever-present submarine menace, which barred several important and conveniently-placed ports.

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Hitherto we have had in mind the demands of the Western front alone, but it must be remembered that Italy, Egypt, Gallipoli, Greece and Macedonia, Sinai and Palestine, Mesopotamia, East Africa, and the N.W. Frontier of India were all theatres of war whence demands were made, and prompt and regular shipments had to be arranged for all of them. What this meant can best be seen by reference to *Plate* I.

The vicissitudes of a campaign may cause a sudden call for stores at the shortest notice, and the gravest issues may depend on prompt supply. Therefore, intelligently to follow the story told in the Graphs, the principal military events should be borne in mind, *e.g.*, if *Plate* V be enlarged and at top or bottom be added the chief battles and events in chronological order, their domination of the demands on F.W.8 will be clearly seen some three to six months later, *i.e.*, the time required to design, manufacture and ship.

Wherever possible, forecasts of operations were obtained by the D.F.W. from the General Staff, and orders placed accordingly, but there were obvious difficulties in this procedure, and liberal allowance had to be made for variation.

1915.—Instead of an advance to the Rhine, the Allied Armies were committed to winter warfare in October, 1914, and found it necessary to develop communications by rail, road and water, so that in place of 2 ft. 6 in. gauge railways and mobile Army workshops the call was for girder bridges and permanent-way for the French Chemin de Fer de l'Est, and for French lines of railway serving our troops, for many thousand tons of road metal, and many hundred thousand gallons of tar, for road bridges and steam-rollers, for all kinds of shell-proof shelters, trench pumps, hand- and power-driven, trench diggers, loophole plates, sap shields, mining machinery, survey and life-saving apparatus for mining companies, newly raised; for petrol- and electrically-driven air pumps for mines, and for thousands of canaries and white mice to test the air of the mines. All these demands came on Major Oakes' branch and were duly provided.

As the warfare of positions dragged on, and miles of water-logged trenches required dewatering, pumps and more pumps were demanded, and in December, 1915, 15,000 pumps and 250 miles of hose were under manufacture, with 150 miles to follow. Demands for steel screw-posts for entanglements, roofing felt, corrugated sheeting, structural steelwork, cement, stoves, and laundry machinery showed clearly that the winter struggle in 1915 would be prolonged and bitter.

In September, 1915, Major-General Scott-Moncrieff (D.F.W.) visited the armies on the Western front to study the engineering needs of the whole theatre, and took Major Oakes with him. This visit bore ample fruit: the military situation from the ports to the foremost trenches had been grasped, a close mutual understanding

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between the military engineering chiefs at the Front and the War Office Suppliers was established, procedure in regard to demands was co-ordinated and simplified, and the good relations then established were continually maintained by periodical visits of Oakes' officers to France, and by visits (to Oakes and his successor) of Engineer Officers on leave in England from all the various theatres of war.

When the campaign in the Dardanelles opened, defence stores were required, and supplies were at once diverted from France, recoupment taking place later. Egypt became a base for Engineer Stores for Egypt itself and all other Mediterranean forces, and the bulk of the contents of the Engineer Siege Parks for France, as well as the complete outfit of 2 ft. 6 in. gauge railways provided for the Western Front (but refused at first by the railway branch), were promptly shipped to Alexandria and were of incalculable value in the subsequent operations against the Turks in the Suez Canal zone.

The endless demands from the various theatres of war entailed many modifications in accepted designs of machines and plant, whilst many novelties were also called for. It was essential that these should be quite efficient under service conditions before dispatch, and to attain this end, an experimental trial ground was established at Claygate, Surrey, under Major Oakes' general supervision. Here, exhaustive trials of tunnelling machines, pipe-pushers, trench-diggers and light and heavy ropeways were carried out. There were many setbacks, but no one acknowledged defeat, and the general consensus of opinion in the field was that the machines thus tried out came up to expectations, and justified the time and trouble entailed in evolving their final and varied forms.

1916.—As the war progressed, one by one the Royal Flying Corps, Military roads and railways and the Inland waterways and docks developed into distinct organizations and took over their own supply problems, thus relieving F.W.8; but, in the meanwhile, fresh problems had arisen on the Western front in connection with water supply, the provision of electric power and light, and the supply of corrugated sheeting and other materials for revetments and temporary shelters for men, animals and stores. It may be noted that the Ministry of Munitions did nothing to relieve the D.F.W. in respect of engineer stores.

East Africa took £51,000 worth of cement, hutting stores and machinery during 1916—a mere bagatelle compared with France, but entailing appreciable additional labour on F.W.8.

Mesopotamia in that year demanded bridges up to 60-ft. span, hot-water apparatus and ice plants for hospitals and camps, and a 1,000-kw. power-station for Basra port to drive 7,000 hospital fans and to manufacture 20 tons of ice daily. To meet this demand, power plant under private order for India was commandeered, and

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dispatched with boilers and all accessories. The boilers were sunk by the enemy, but the Branch managed to ship a fresh outfit in eight weeks, and the power station was at work in April 1917.

The Mediterranean base took a million pounds' worth of engineer stores in 1916, of which internal-combustion locomotives and aerial ropeways were notable items.

1917.—England began to suffer from German air raids in 1917, which called for anti-aircraft guns and lights, and these latter, with small sets to work them, were provided by F.W.8 with difficulty, as manufacturers' hands were at this time very full, and steel was scarce.

On the Western front, as a result of the battles of 1917, the British Armies were established in country where roads, railways, villages and towns, water and lighting supplies had been systematically destroyed. The use of tractor-drawn guns and the advent of tanks demanded complete reconsideration of bridge girder designs. The Channel ports were systematically and continuously bombed, whilst Labour Corps swarmed on all Lines of Communication and required immediate shelter to preserve health. Timber could no longer be supplied in vast quantities from England, and the French Government allotted forests to the English armies for their needs. Lastly, the policy of cultivating the devastated areas in rear of our armies was initiated, to provide green food and fodder.

Another spell of trench warfare was indicated and, to meet these various needs, vast quantities of cement, entanglements and posts, corrugated sheets, roofing felt, steel shelters, piping, tanks, rolled joists, and expanded metal sheets were dispatched monthly, in addition to agricultural machinery, large log-saws and sawmill plant, to say nothing of special plant and machinery for water supplies and electric power. Twenty-seven thousand "Nissen" huts were demanded in March, 1917, and 20,000 more a few months later. The first order was completed by the autumn, but steel and other difficulties threatened serious delay to the second 20,000. For the same reasons, 53,000 stoves under manufacture seemed at one time impossible to obtain, but the officers of F.W.8 strained every nerve, and 43,000 had been shipped to France by 31st December, 1917.

Deep well-boring plants, pumps and air lifts, centrifugal, reciprocating, ram and turbine pumps solved the problem of water supply under very varying conditions, whilst in one case, a 22-in. Gwynne centrifugal and 6-cylinder 90 B.H.P. engine, delivering 600,000 gallons per hour, successfully drowned out certain German trenches which it was necessary to suppress. Risk of disease, too, had to be met and countered by water-purifying plants. In the smaller of these, crude water was treated with sulphate of alumina and soda, the water passing to sand filters before use. In larger installations water was chlorinated and dechlorinated, and portable chlorinating plants were manufactured and sent out.

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The *Official Medical History of the War* states that, whereas in S. Africa of 530,000 troops employed 58,000 had typhoid and of these 8,000 died, in the Great War 5,000,000 men entered the war areas, and amongst them were 7,500 cases of typhoid and 266 deaths from this disease, thus attesting in a remarkable way the efficacy of water-purification as a preventive.

Mention may also be made of plants for X-ray sets at Forward Clearing Stations, the supply of which fell to F.W.8.

The tale of special plant included laundry and wood-working machinery, machine tools, fire engines, destructors, disinfectors, cranes and concrete mixers for the construction of blocks for " pill-boxes "—small strong points in the front line capable of withstanding the heaviest bombardment.

Supplies for American Armies. 1917–1918.—In April, 1917, the United States declared war on Germany, and it was agreed that the Armies of our Ally should be supplied, as far as possible, from England, notwithstanding the increasingly serious position of the markets for steel and all raw materials, and the shortage of skilled labour in England. The American Engineer Purchasing Officer in London (Colonel R. G. Powell, C.M.G., U.S. Engineers) got in touch with the Chief Mechanical Engineer, and the cordial relations then established increased under the stress of war. The various demands of the British Army already enumerated now came in, in an increasing flood, from the American Base Depôt in London, and taxed the hard-worked staff of F.W.8 to the utmost. But the best of good fellowship prevailed, and the demand for units of baking plant to supply a total of 1½ million bread rations per day was met with a smile and a laugh, and the plant was, in the main, supplied in due course. On taking leave of England in 1919, Colonel Powell expressed, in cordial and graceful terms, the boundless appreciation of the American Expeditionary Force and the U.S. Engineers and their debt to the Chief Mechanical Engineer's branch. Between August, 1917, and December, 1918, the American Armies had been supplied with engineer stores to the value of £1,500,000.

In Mesopotamia the Turks had retreated 30 miles north of Baghdad by 18th March, 1917, and Sir Stanley Maude decided to cultivate cereals and fodder in the Tigris and Euphrates valleys to relieve the strain on India and on shipping from Indian ports. Pending the construction of canals, water reached the land by means of powerful pumps and engines sent by F.W.8, and he also managed, after much difficulty and labour, to fill demands for numbers of " spares " for hundreds of pumps and engines of English manufacture, seized as prize of war. Little beyond the names of makers and very meagre descriptions of the machines were cabled, but these, with the makers' help, proved sufficient in the majority of cases. An exactly similar experience occurred in 1918, when General Allenby seized Palestine.

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1918.—Mesopotamia, in pursuance of the agricultural policy, also demanded hay-balers, corn-crushers, ploughs and harrows, all of which were on the sea by May, 1918. In this last year of the war, General Marshall's forces also received a 9-unit milling plant, and several dairy plants, whilst former orders for oil-driven pumps (6 in. to 20 in.) and agricultural instruments were repeated.

The port of Basra was being rapidly developed, whilst large railway shops were to be located at Baghdad. In June, 1918, the power available at Basra (1,700 kw.) was to be replaced by a large turbine set to meet the increasing requirements of docks and wharves, the bulk of the three existing installations being earmarked for transfer to the Baghdad railway shops. With the signing of the Armistice by the Turks, the scheme was abandoned, though much of the necessary plant had reached F.W.8's stores at Abbey Mills.

A small British detachment ("Dunster Force"), operating in the direction of Enzeli and the Caspian, was dependent on a precarious Line of Communication over mountainous country between Mesopotamia and Hamadan. To aid in passing in supplies, F.W.8, after long and patient experiment, had evolved a satisfactory monocable "general utility" ropeway capable of handling at least 360 tons *per diem* in 5 cwt. loads, 30 per mile. In August, 1918, 50 miles were under manufacture for the benefit of Dunster Force, but it was not required, owing to the sudden termination of hostilities in Mesopotamia in November, 1918, and was stored in England for future eventualities. Similar units were manufactured for use in the Balkans, and these, too, became surplus in November, 1918. But in the following year the Indian Government were in difficulties regarding transport in the Khyber, and gladly took 70 miles, which proved very useful. Everything in the outfit had been standardized, and spans of 1,000 ft. could be negotiated, with standards 64 ft. high if required. The engines were of 40 h.p. and required 30 gallons of petrol and 3 gallons of oil per hour. The outfit required for average country, delivered at F.W.8's store, cost £2,000 per mile in 1918.

The course of events in Palestine during 1917 and 1918—from the first attack on Gaza to the brilliant capture of Damascus and Aleppo—cannot be followed in detail, but the consequent reinstatement of roads, ports and water supplies and the varied needs of camps and hospitals created an unending series of difficulties for the Engineers, who relied on F.W.8 for all machinery and stores, and no call was made in vain. The story of the Allenby bridge over the Jordan may be taken as a fair illustration of the demands and how they were met.

An Inglis heavy rectangular bridge, 240 ft. over all, was demanded by cable on 7th April, 1918, and was landed on 1st July at Alexandria, complete with all erecting gear, by an R.E. Territorial Subaltern who had been selected to take charge of the consignment

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so as to ensure delivery of the thousand packages intact. This officer was attached to the Army in Palestine and took charge of the bridge, and in August and September erected it just north of the Dead Sea, 1,200 ft. below the level of the Mediterranean, in the very hottest season of the year—a fine piece of work.

During 1917 and the greater part of 1918 General Milne's forces in Greece and the Balkans could make but little headway, notwithstanding strenuous exertions and unremitting toil, until at last their chance came, was seized and ended on 30th September in complete victory. During those 20 months the forced inaction, the mountainous, and in many places marshy, nature of the theatre created special difficulties, and necessitated the supply of quarrying machinery for road metal, hutting and building materials for improved camps and hospitals, water supplies, lighting sets and multifarious machinery, destructors, disinfectors, and water-purification plants, to combat disease.

In 1917 it was clear that supplies of French charcoal for the British Armies could not be depended on, so the Chief Mechanical Engineer was directed to build and equip with special machinery a peat-fuel factory at Dumfries, and the first consignments of fuel were ready when the Armistice was declared. As France no longer required it the fuel found its way to garrisons in England and Ireland.

The great German attack in March and April, 1918, caused heavy losses of huts, water supplies, machinery and tools of all kinds. Whilst it was necessary to replace these losses, though F.W.8 were working at very high pressure already, the highest authorities contemplated that 1919 would also be a year of war, and called on F.W.8 to maintain in full the tale of monthly "maintenance" stores, and added demands for 20,000 fresh huts and 15,000 steel circular tents, for over 1,000 bridges of spans from 21½ to 120 ft., and in addition for a special equipment of bridges for tanks which were themselves to carry and lay them. Large electric power plants for Boulogne, Calais and Yvetot were urgently required to supplement the French installations, now heavily overworked, and four bakery units, each with a capacity of half a million rations daily, were under manufacture for British Armies in France.

During the struggle on the Western front, camouflage was used more and more extensively, and F.W.8 provided hundreds of thousands of fish-nets, miles of canvas and coir screening, calico and hessian, all of which were required to be made fireproof. This problem presented many difficulties and entailed much experiment and research and repeated failures. In November, 1918, success had just been achieved when the Armistice caused demands instantly to cease, but the records of trials and results remain for future use and should prove of value if the need arises.

Plates I and II show comprehensively the value of engineer stores

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ordered and inspected, and *Plates* IV and V the tonnage shipped through the fateful years 1914-16, but owing to circumstances which Oakes could not control his office accommodation was miserably inadequate; *e.g.*, the nine officers of the branch, dealing with masses of orders, contracts and bills were working in one room at the War Office with four telephones in use—and the strain under such conditions may be imagined. On 1st April, 1917, Oakes installed his branch at Adastral House, Blackfriars, and in the Army Order sanctioning a larger staff for the Chief Mechanical Engineer his duties were thus defined: "The purchase, inspection, shipping, store accounting, and in some cases, design, of machinery, mechanical engineering plant and engineering stores for Expeditionary Forces and Colonial Stations, and any special machinery, mechanical plant and structural steel work for Home Stations."

The framework of the new organization was in two parts: (*a*) design, purchase and inspection; (*b*) shipping, store accounting, finance and general correspondence. The backbone of the structure were the "section officers," of whom there were six on the design and purchase side and four on the shipping side. To each were allotted specific duties, *e.g.*, on the design side, Section 1 dealt with hutting and building stores; Section 3 with special machinery; Section 5 with electrical and pumping machinery, and so on.

At the S.W. India Docks was Quartermaster and Hon. Lieut.-Colonel Tucker, Assistant Director of R.E. Stores, with section officers dealing with (i) shipping, (ii) store depôts, (iii) accounting; the whole under the general control of the head of the Shipping and Accounting side of the Chief Mechanical Engineer's office—Quartermaster and Hon. Capt. (afterwards Major) A. Walker, R.E.

On the design side the section officer received the original demand from overseas and kept a grip of it through all the stages of design, tender (when this had been accepted by the C.M.E.), contract, inspection and completion of manufacture. Then the section officer handed on the documents to the shipping side to be dealt with. All documents and correspondence were carefully filed together, and the section officer knew not only the life history of any order, but could assess the value of the contractor. The latter also learnt to know and appreciate his section officer, and this mutual knowledge and respect bore ample fruit after the Armistice, when the branch proceeded to liquidation of outstanding contracts.

The Section officers were all experienced Civil Engineers: some were specialists, and some had been wounded and were unfit for futher service in the field. They thus had both military and civil knowledge, and were able to gauge the essentials of plant and machinery required by the armies in the field, and boldly adapted or altered accepted commercial designs to suit individual cases as they arose. Section officers were ably assisted by younger Civil

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GRAPH—SHOWING QUARTERLY DEAD-WEIGHT TONNAGE SHIPPED OVERSEAS.

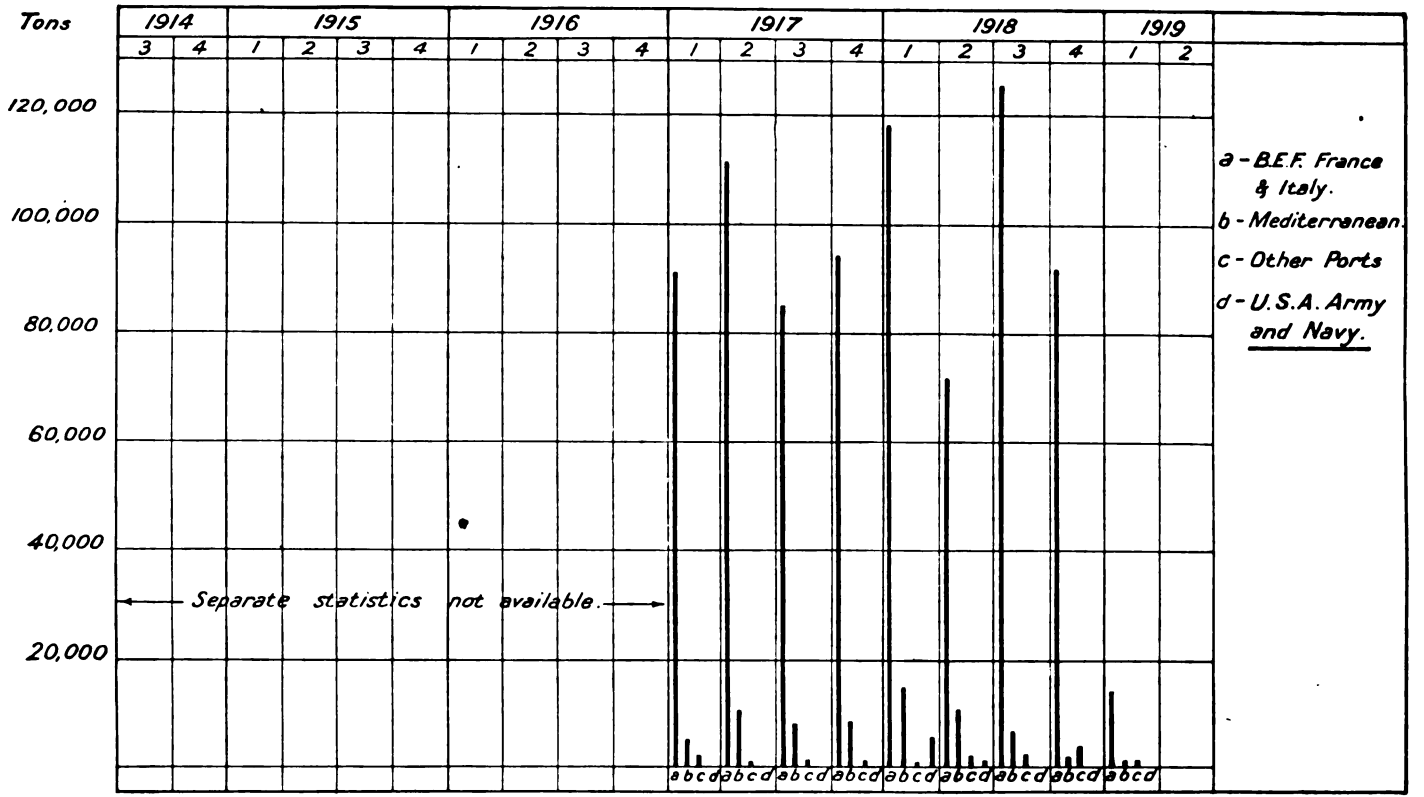

PLATE I.

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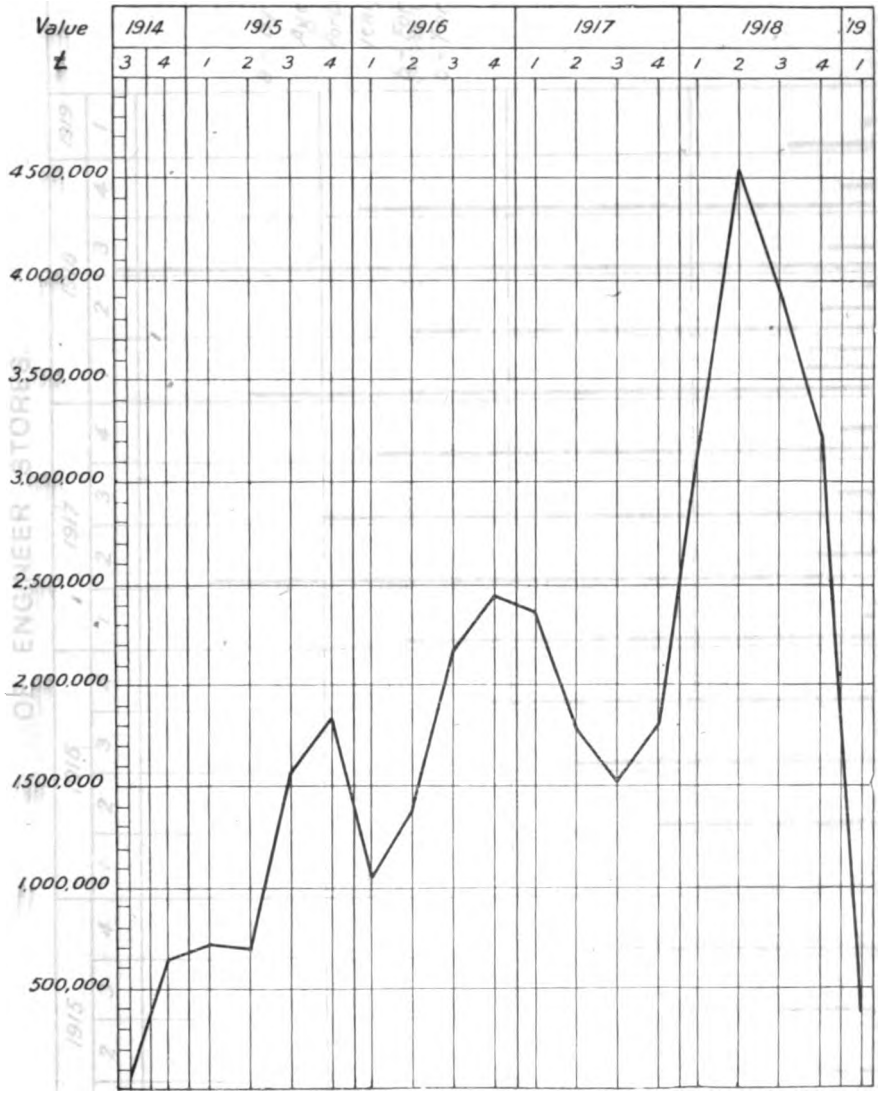
GRAPH—SHOWING TOTAL QUARTERLY VALUE OF STORES ORDERED AND INSPECTED.



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GRAPH—SHOWING QUARTERLY SHIPPING TONNAGE OF ENGINEER STORES.

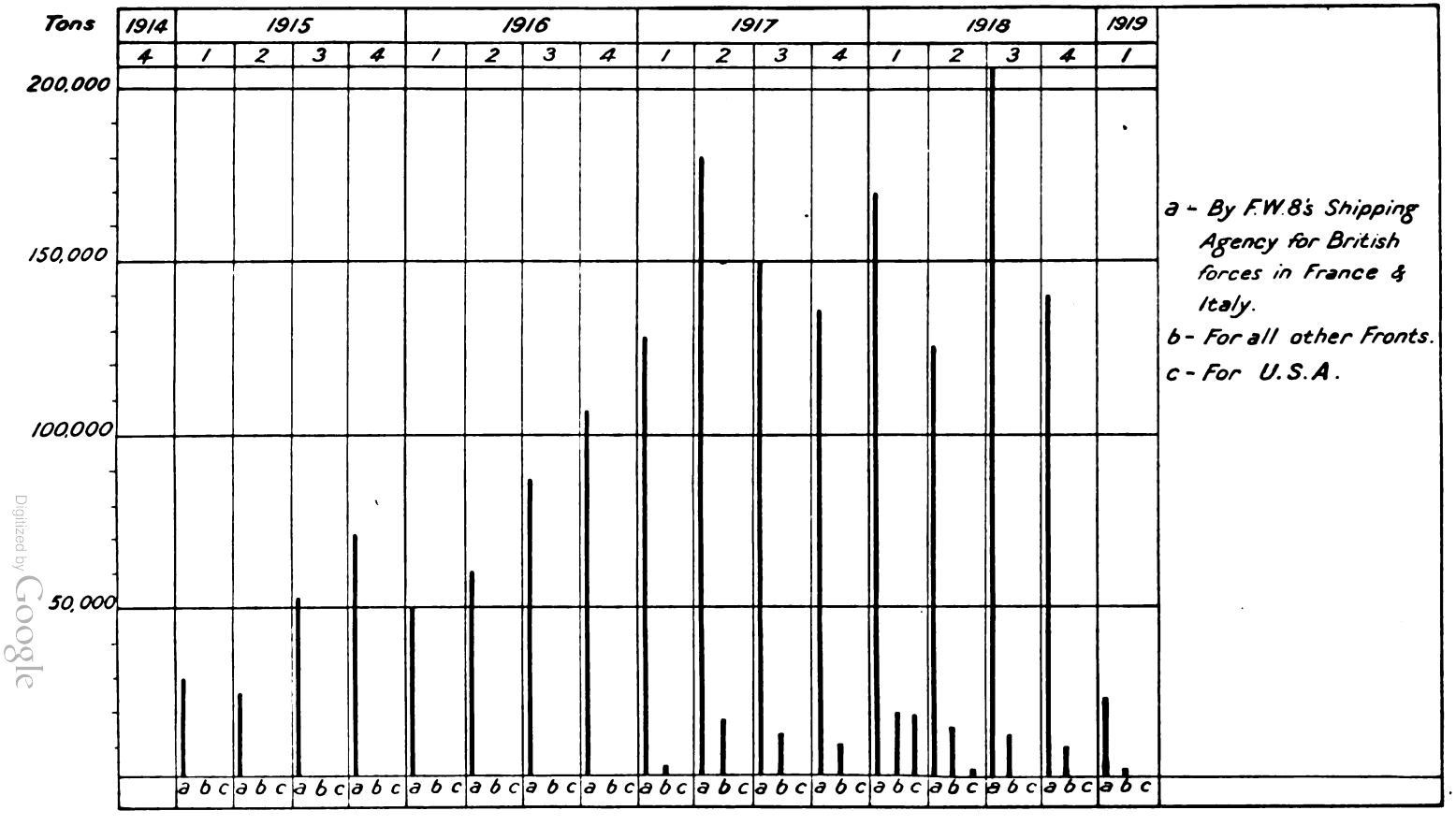

PLATE III.

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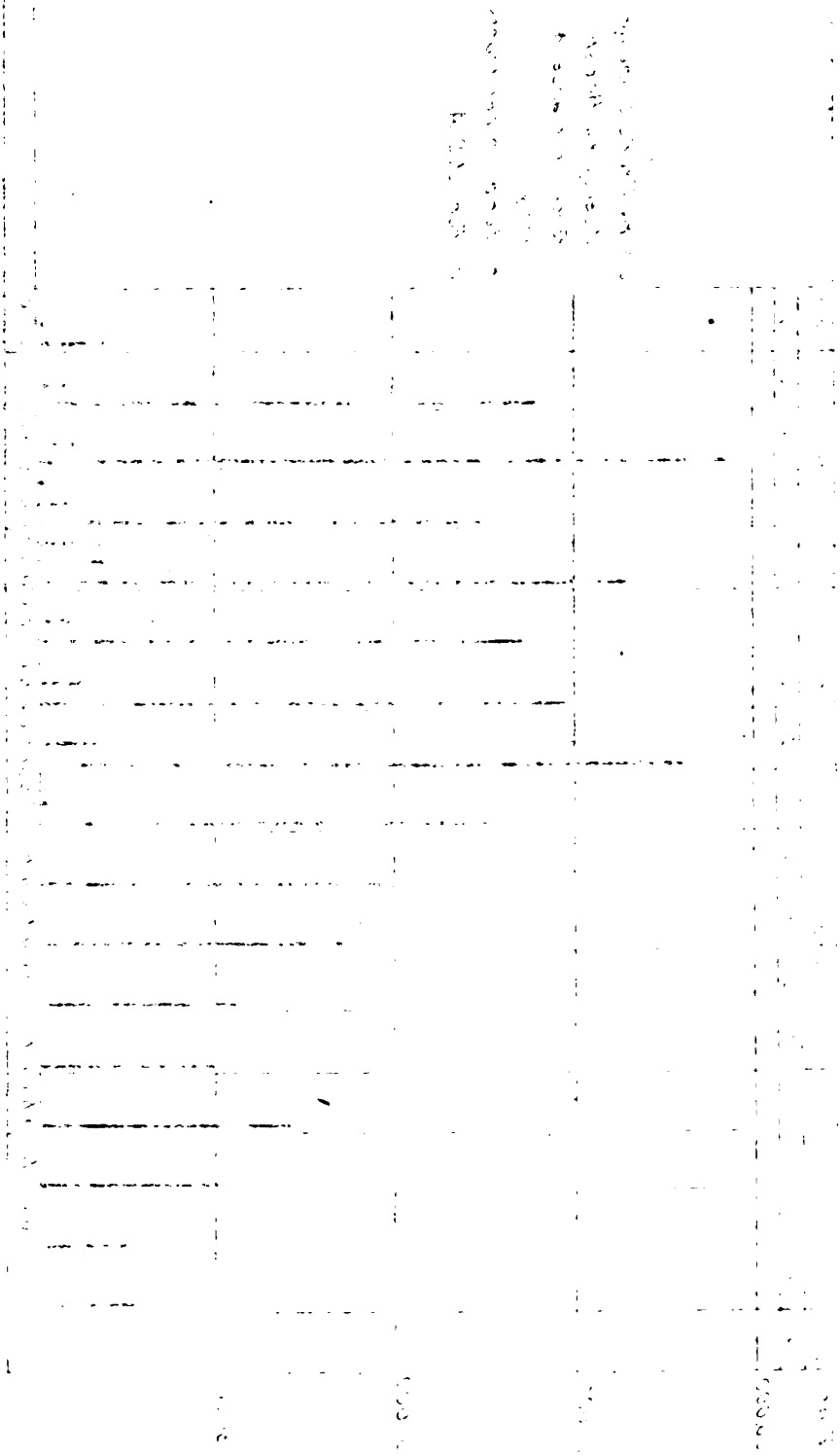

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GRAPH—SHOWING QUARTERLY VALUE OF ENGINEER STORES ORDERED AND INSPECTED.

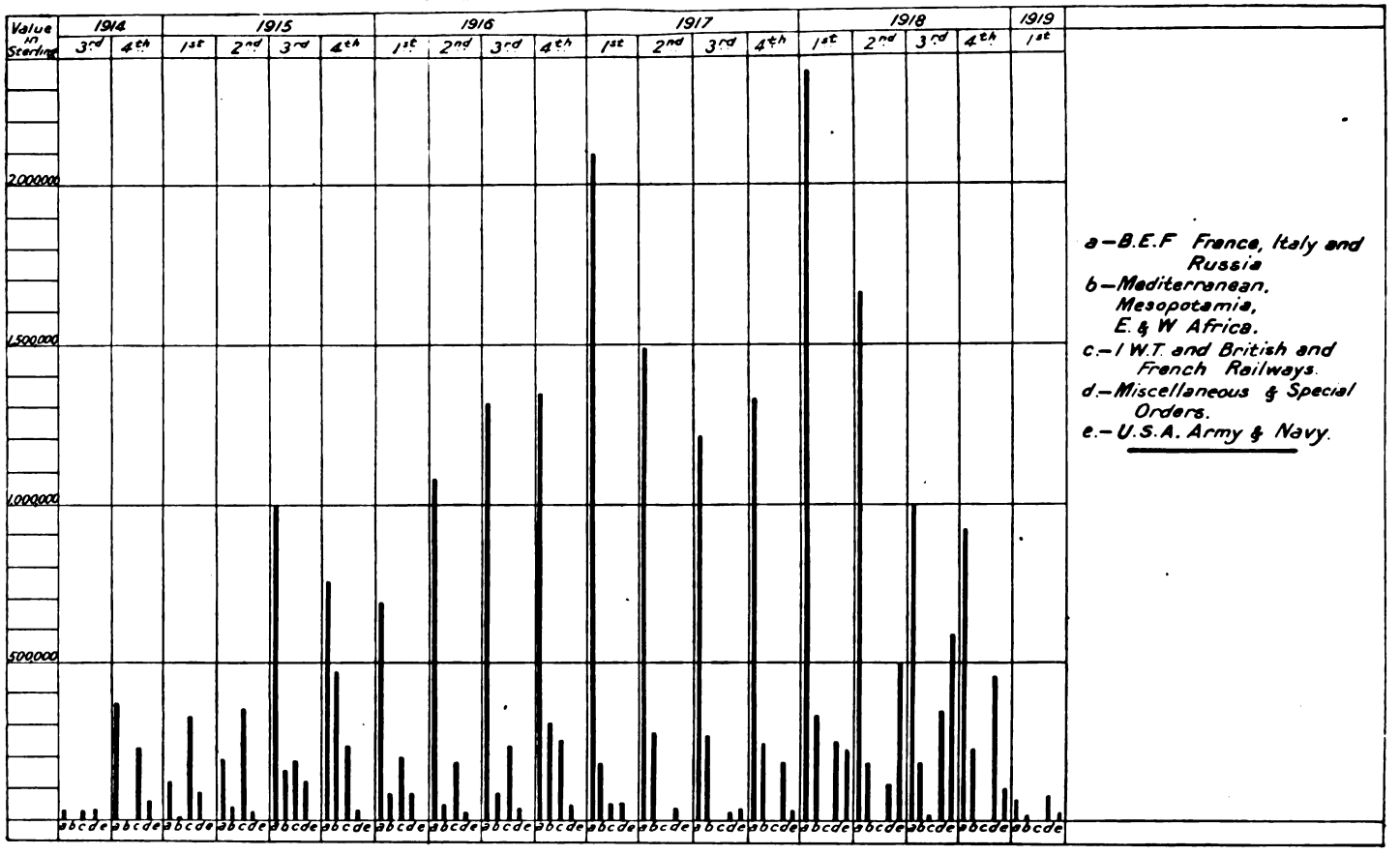

PLATE IV.

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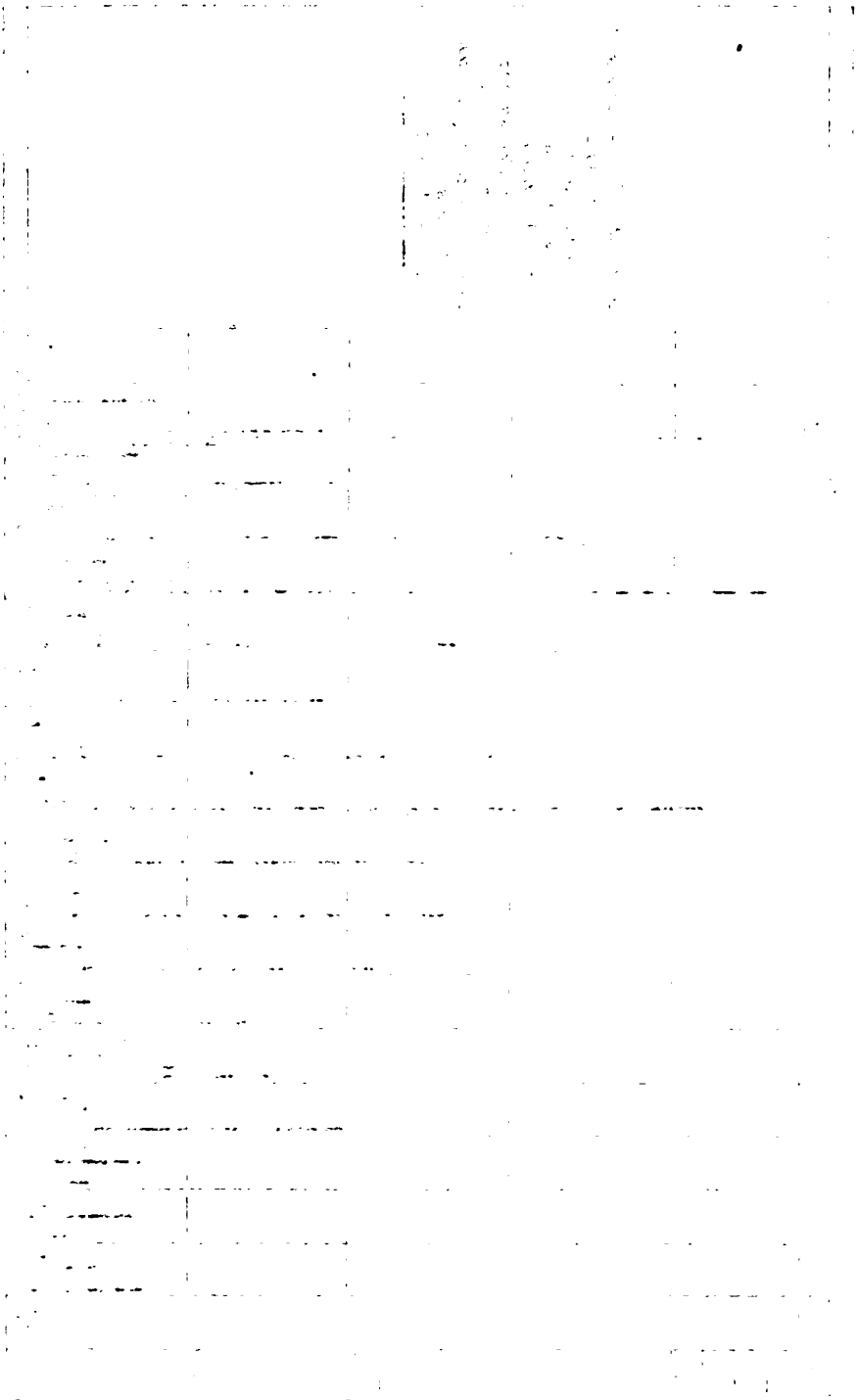

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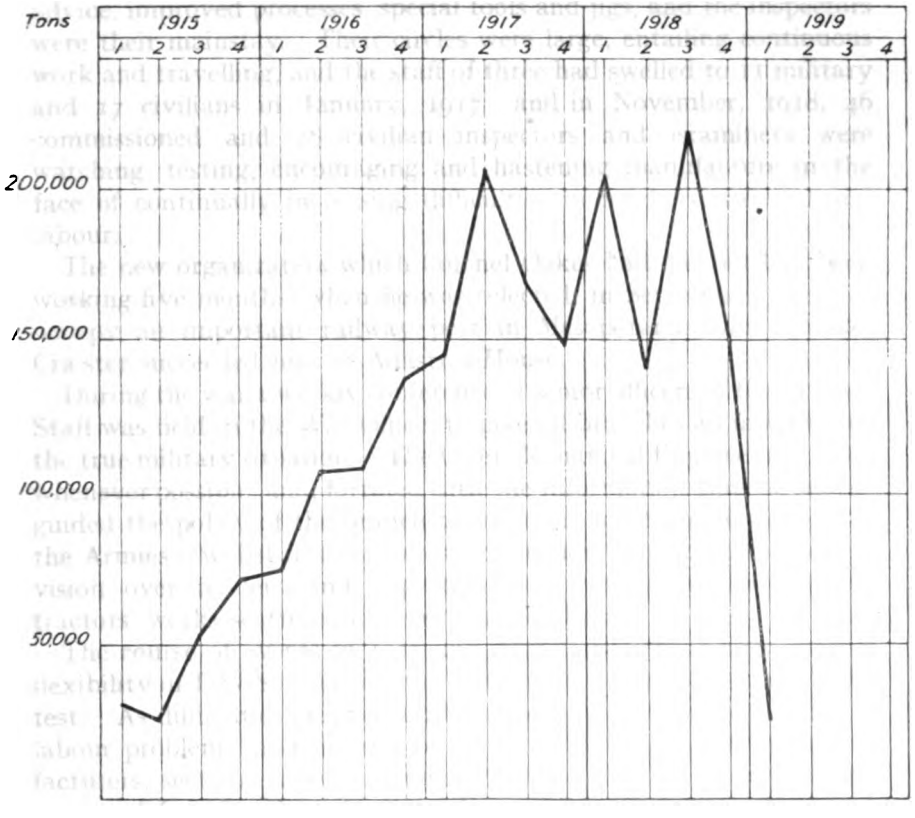
PLATE V.

GRAPH—SHOWING TOTAL QUARTERLY SHIPPING TONNAGE OF ENGINEER STORES TO ALL FRONTS.



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Engineers whose enthusiasm compensated for any lack of experience and enabled those who were unfit for further field service to triumph over physical disability.

The shipping and finance sections were similarly organized, based on the section officer, and thus the foundation was laid to ensure the attainment of the first two principles enunciated, *viz.*, (i) rapidity of supply, (ii) economy in price.

There still remained the third principle, *viz.*, efficiency of inspection. In peace three military mechanists, R.E., sufficed to carry out these duties, but under stress of war many contractors undertook work they had never contemplated in peace. They required constant advice, improved processes, special tools and jigs, and the inspectors were their mainstay. Their circles were large, entailing continuous work and travelling, and the staff of three had swelled to 11 military and 17 civilians in January, 1917; and in November, 1918, 46 commissioned and 28 civilian inspectors and examiners were watching, testing, encouraging and hastening manufacture in the face of continually increasing difficulties in markets, material and labour.

The new organization which Colonel Oakes had created had been working five months, when he was selected, in September, 1917, to occupy an important railway post in Mesopotamia, and Colonel Cra'ster succeeded him at Adastral House.

During the war a weekly conference of senior officers of the General Staff was held in the War Office, to give all branches an insight into the true military situation. The Chief Mechanical Engineer attended whenever possible, and, fortified with the information thus obtained, guided the policy of the branch to meet the most pressing needs of the Armies; whilst in the interests of economy, he exercised supervision over tenders, and inspection during manufacture in contractors' works scattered all over the kingdom.

The course of events in 1917 and 1918 tested the soundness and flexibility of F.W.8, essentially a War Organization, and it stood the test. As difficulties cropped up in connection with supply of steel, labour problems, and priority of supply of raw materials to manufacturers, sections threw off sub-sections, and still the organization grew and functioned efficiently and smoothly. When the Armistice was signed the Headquarters of F.W.8 at Adastral House numbered 49 officers and 143 clerks and draftsmen, as compared with a total strength of 29 of all ranks on the first day of the war.

The average monthly expenditure during 1918 (*see Plates* I and II), was £1,242,000, and the total from August, 1914, to March, 1919, £32,250,000. The cost of administration on the other hand,, worked out to less than 0·66 of a penny per pound sterling of stores delivered, and when it is remembered what were the duties laid on the Chief Mechanical Engineer, it is fair to claim that the fourth

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guiding principle, *viz.*, economy of administration, was acted up to. The Civil Engineers in the branch had borne their full share in attaining victory. They displayed efficiency and tact, grit and superlative loyalty, and all ranks, without exception, were fired with a grim determination to win the war.

Subsequent to November, 1918, demands still continued (though on a rapidly decreasing scale) for the armies in the field, now cantoned in the late theatres of war, and for troops operating in North Russia, on the shores of the Black Sea, and in Mesopotamia.

The demand for a reduction of staff immediately the Armistice should be signed had been foreseen, and proposals had been summitted in October, 1918. In consultation with the Finance Branch, War Office, the principles which should govern the liquidation of F.W.8 commitments were laid down.

These were (i) to ascertain the legal position in respect of every contract then current; (ii) to effect cancellations at the least cost, compatible with real economy to the State; (iii) to leave with contractors part-finished goods only of use to those particular firms—*e.g.*, engine cranks—and to take into store, for issue or sale, only raw materials at full invoice value, or completed articles at full contract value.

The Section officers were evidently those best fitted to open negotiations with contractors, and this was done. After full discussion with the contractor, section officers' proposals were put up to their seniors, and after consideration the complete case, with the Chief Mechanical Engineers' recommendations, was passed to the Finance Branch, War Office, for disposal. The final decisions arrived at were communicated to all concerned, and an early settlement effected. The advantage of recording the history of each separate demand in full detail was soon apparent, for, although section officers were demobilized one after another, the officer selected to carry through liquidation was never at a loss for information, with the records before him, and in the end in only three cases did contractors threaten legal proceedings, and of these, two cases were withdrawn. The following liquidation figures for F.W.8 are of interest :—

Value of contracts settled *without any compensation*	... £795,000
,, ,, ,, with compensation *under* 15%	... 543,000
,, ,, ,, *exceeding* 15%	... 225,000
	£1,563,000

The compensation paid was £87,593, or 5·60 per cent. of F.W.8's commitments. The Select Committee on national expenditure, criticizing the operations of another Government department, states that the figures as at 31st March, 1920 were 42·3 per cent. for contracts

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liquidated in England and 60 per cent. for contracts closed in the United States.

With the advent of the Armistice it had been agreed by the U.S. Army Authorities that F.W.8's contracts made on their behalf should be liquidated by him, on a basis some 50 per cent. higher than the compensation on English Army Orders. Those contracts were duly closed to the complete satisfaction of Colonel Powell, C.M.G., U.S. Engineers, and the figures are not included in the total above.

On July 1st, 1919, the duties of supply were transferred to the Ministry of Munitions, but during the seven months ending 30th June, 1919, the Chief Mechanical Engineer placed orders valued at £936,000, and from existing stocks complied with demands from Home and Colonial Stations to the value of £595,000. The Shipping and Store Accounting Sections were busy dealing with all stores delivered. By 1st August, 1919, they had shipped 50,000 tons overseas, had arranged for war reserves, and had listed and passed the remainder to the Disposals Board. The Finance Branch of F.W.8, meanwhile, examined and passed for payment over 16,000 bills, aggregating £4,795,000, including arrears at the Armistice. Reductions in staff began early in December, 1918, and on 1st August, 1919, when the Chief Mechanical and Chief Electrical Engineers' branches were amalgamated under the latter, F.W.8's staff numbered 24 officers and 55 other ranks. By May, 1920, the numbers had been further reduced to five officers and 11 other ranks, and by 31st March, 1921, these had been gradually extinguished and F.W.8 had become a memory.

Major-General Sir George K. Scott-Moncrieff, K.C.B., K.C.M.G., C.I.E., and Sir William A. Liddell, K.C.M.G., C.B., who were present at Bristol, addressed the University authorities and the Engineer students on the conclusion of the lecture.

Sir George Scott-Moncrieff reminded his audience that the Engineers' object was to "deliver the goods" as quickly and economically as possible: his reward lay mainly in the joy of achievement. He pointed out that engineering in war embraced not only mechanical work to produce munitions, but an immense amount of work in the field, corresponding closely to that of a Municipal Engineer in time of peace, with this difference—that in war such work must depend on local circumstances and the military situation at any given moment. Thus, at the outbreak of war in 1914 the Engineers at the War Office could not become really busy till the campaign developed Then they took the matter in hand, and the branch whose history they had heard was one of twelve which were evolved under him (as Director of Fortifications and Works) as War Organizations. The splendid staff of officers, military and civil engineers who did the

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work, were not those who advertised their exploits, but were typical of the bull-dog breed that has built the British Empire.

Sir William Liddell defined the leading characteristics of the Military Engineer thus: Ability to adopt expedients, and ability to realize the value of time, to obtain tangible results consistent with efficiency. Referring to the University students who would go abroad as "Pioneers of Empire," he advised them to study the history of the work of the Engineers in the Great War, as the engineering problems they would meet in the course of their employment bore a strong family resemblance to those in war, chiefly owing to paucity of means and lack of machinery.

Thus the Military Engineer could help his Civilian brother and each should foster and keep fresh the comradeship engendered by a common participation in the trials of the Great War.

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RECENT DEVELOPMENTS IN WATER ELEVATORS.

By MAJOR G. C. GOWLLAND, R.E., A.M. I. MECH. E.

THE inventor of the Persian water wheel would be gratified could he read the new *Water Supply Manual*, for on *Plate* XLVII of this publication he would find a drawing of his ancient patent elevator, together with the following description :—

> "The Persian water-wheel (or *sakia*) elevator is a hand- or animal-driven water-lift of extreme antiquity. It is suited for low lifts where continuous delivery is required, as for irrigation purposes."

Early forms of other types of machinery are not honoured with full-plate illustrations in other volumes of the *Manual of Military Engineering*, and it therefore appears that there must be something fundamentally sound in the age-old *sakia*, or it would not be mentioned or illustrated in a modern military publication.

The *sakia* consists of a wheel suitably mounted in a vertical plane directly over the water supply, and there caused to rotate. On this wheel are slung a pair of endless ropes to which are attached at intervals a number of earthenware vessels, small tins or other water receptacles. The ropes are made long enough to reach the water.

As the wheel revolves, the rope goes round the wheel, and a continuous stream of water-filled receptacles is brought up and discharged into a suitable receiver as they top the vertical wheel. A simple invention, yet it has lived, and all modern elevators work more or less on the *sakia* principle ; the more successful being close copies of the original.

The chief good points about the *sakia* are :—

(1) No fixed parts down the well ; therefore, the whole installation can be done at the well-head without going below ground. There being no rigid fixtures down the well means that shaky steining can be ignored.
(2) Positive action. However slow the belt speed, some water is bound to come up.
(3) The lift is not limited to some 25 ft. as in a suction pump.
(4) No skilled supervision is required.
(5) Spare parts can be easily improvised.
(6) It works well with animal power as its prime mover.

A most excellent appliance for getting water out of roughly steined wells that are too deep for a suction pump to work from ground

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level. The writer was, in fact, asked in 1916, to design a portable *sakia* capable of raising water from 200 feet depth for use with a desert column. Some such elevator obviously is wanted, but the *sakia* is no good for military purposes, for the following reasons :—

(1) It is not portable, and cannot, in its ancient form, be made so.
(2) It cannot be speeded up. Any attempt to get high belt speeds causes the efficiency of the water receptacles to drop to zero, owing to air displacement difficulties.
(3) It is incapable, owing to mechanical weakness, of raising water from much above 50 feet.

With the innumerable well-designed pumps that are now being produced, it may be asked why water elevators come into the picture at all. The chief reason why these elevators are being produced is on account of the ease with which they can be fixed, and the fact that they have no fixtures below ground level. This renders them particularly useful for military work, or for situations where quick installation is necessary and where skilled supervision may be at a reduced minimum ; *e.g.*, for farm, colonial or country house use.

In order to make the *sakia* of use for military and other purposes, inventors have tried to cut out its three main faults.

Two such improved designs, the Canvas Belt and Chaîne-Hélice, are described in the *Water Supply Manual*, whilst a third, the Caruelle, is mentioned, but misnamed the Carnalle elevator.

In the Canvas Belt elevator the positively acting water lifting cups on the endless ropes used in the *sakia* are replaced by a broad canvas belt, in which the water is partially absorbed and partially retained by capillary action on the hairs of the belt. By this method belt speed can be increased, in fact the higher the belt speed the better, since there must be always a certain amount of " slip " in the water on the rising side of the belt. The higher the speed of the belt, therefore, the greater will be the difference of speed between the ascending side of the belt and that of the water that is tending to slip down the belt under gravity, and in consequence the greater will be the output. In other words, the action of the belt is not positive, and if the belt moves slowly, the output of water will be very small, firstly because the slip will be great, and secondly because there will not be sufficient centrifugal force to throw the water off the belt as it reaches the top of the pulley.

The belt elevator answered well in many respects for military purposes, as it was light, fairly portable, and very rapidly installed, but it had several bad faults.

(1) It was not positive in action, and therefore had to be run at speed. This entailed the use of some type of engine, usually internal combustion, not always very portable, but ever hungry for spare parts and skilled supervision.

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(2) The lack of positive action cut out the useful employment of men or animals as prime movers, firstly, because in order to get belt speed from a slow moving beast it is necessary to use a lot of heavy, not over-portable, gearing at well-head, and, secondly, because if the prime mover, a mule or ox for instance, stops or slows down for any reason, the belt speed drops and down goes most of the water on the rising side of the belt, and the efficiency drops enormously.

(3) The belts wore out quickly if run at economical output speed. This entailed the cartage of spare parts and reduction in portability.

(4) Finally, the efficiency was low. When run at high speeds, so high that the belts quickly wore out, the overall efficiency of the belt outfit is about 35 per cent. Thus the actual belt efficiency would be about 65 per cent.

Water can be raised by means of the canvas belt from depths up to 200 feet, the output being from 1,500 to 2,000 gallons per hour for a single belt. This elevator, in eliminating the three main faults of the *sakia* has eradicated all its good points. There is no demand for the Canvas Belt elevator in civil life; it is, in fact, a makeshift, and was used in war time because nothing better had been thought out. It would probably not be much good for watering desert columns on the move, owing to its non-positive action.

The Chaîne-Hélice is another form of elevator. In this case water is brought up on an endless chain surrounded by coils of wire that move with the chain, and are fixed to it at frequent intervals. The water is held between the spiral and the chain by surface tension, and as the chain goes over the upper pulley, the water is thrown off by centrifugal force.

The action of the Chaîne-Hélice is, therefore, non-positive. The chain speed is about 850 feet per minute as against the 1,600 f.p.m. necessary in the canvas belt. The overall efficiency is between 30 per cent. and 40 per cent., giving an efficiency of the chain itself of between 65 and 75 per cent.

Water can be raised from a depth of 300 feet, and with suitable gear at well-head the elevator can be worked by man or animal power, but being non-positive in action its efficiency will drop off rapidly as the speed of the chain slacks off.

This elevator was much used during the late war, some 400,000 yards of chain being supplied for water supply services. It was found, however, that under service conditions chains were liable to frequent breakage. The outfit is portable, but probably not portable enough for use with camel, mule, or other pack transport.

The weights of complete Chaîne-Hélice outfits are shown later, where they are compared with the weights of the Caruelle outfits of similar capacity.

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The third type, known as the Boulton Water Elevator is made by Messrs. Boulton & Paul, of Norwich, and in it is incorporated the Caruelle patent water elevating belt.

The inventor of this has taken the *sakia* as his model. He has incorporated in his invention all the good points of the old water-wheel, and has cut out most of its faults, producing what appears to be a most excellent elevator from the military point of view.

The action of the Boulton elevator band is positive. The band itself consists of a series of open-ended cells attached to an endless belt. The form of these cells, and their method of attachment to the belt, are shown in *Fig.* 1. The cells being open-ended are capable of being filled even if they are passed rapidly through water, but they are so designed that when held in a vertical position the water is retained in them, even though the belt be stationary. The moment, however, that the belt is inclined, the water flows out of the cells. This effect is shown in *Figs.* 2 and 3, and is somewhat remarkable.

The result of the use of this cellular belt is that water will be elevated no matter what speed the belt is run at. Therefore man power or animal power can be usefully employed, as no matter how slowly the belt moves, or how often it stops, the supply of water in the rising side of the belt will not be entirely lost. On the other hand, if it is convenient to drive the belt at speed by means of an engine, it still remains efficient. The Boulton band is designed so that various units can be placed side by side and so increase the water-lifting capacity in direct proportion to the number of units used.

Fig. 1 shows the single unit. This is mounted on a special metal strap (A), while the multicellular bands, as shown in *Fig.* 4, are made up of a number of single units as in *Fig.* 1, mounted close together on a Balata belt. Tests on a single element band (as *Fig.* 1) show that at a speed of 400 feet per minute the efficiency of the band is 95 per cent., the overall efficiency of an elevator run at this speed being 57 per cent. The single element band lifts at this speed 355 gallons per hour from a depth of 152 feet.

Fig. 5 shows a section of a Boulton elevator fixed in a well. From this it is seen that there are no fixtures down the well, and that the whole apparatus can be quickly erected at the well-head.

This elevator appears to be the solution of the portable *sakia* problem.

Desert columns will, as a rule, have camel transport, supplemented in favourable places by motors.

For the moment, consider the problem of a column with no motor transport, operating across desert country, the only water supply being from deep wells usually a long day's march apart. These are the normal conditions in many parts of Africa and Arabia.

The column of tired men and camels arrives at its halting place; both men and camels are thirsty. The wells are, perhaps, 200 feet

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RECENT DEVELOPMENTS IN WATER ELEVATORS.

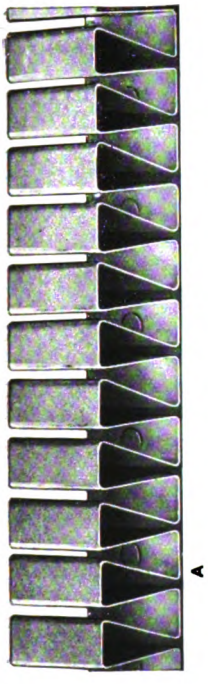

Fig. 1.

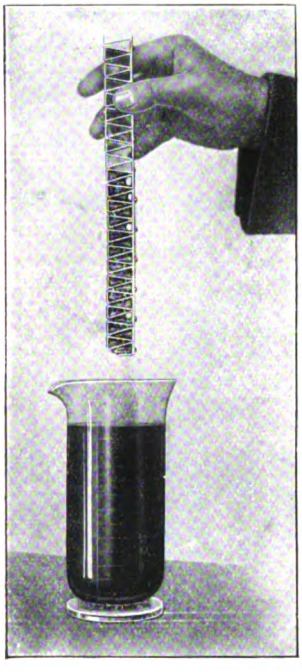

Fig. 2.

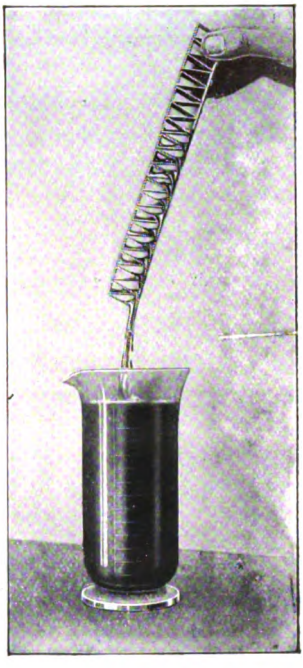

Fig. 3.

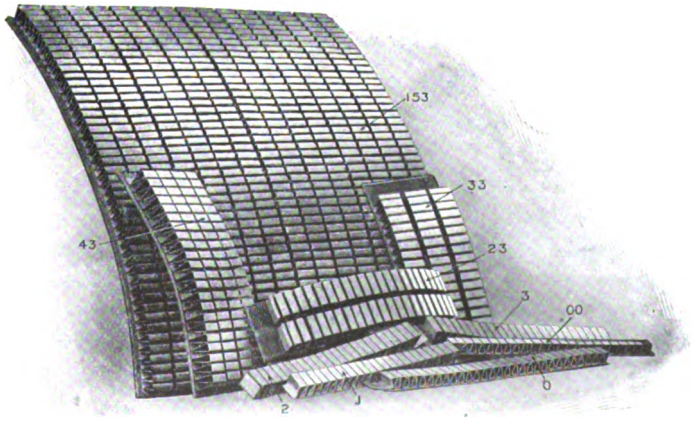

Fig. 4.

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deep; water has to be got up. The usual method employed is, in the case of irregular troops, for each man to carry a small *dilwa* or leather bucket with a long rope. With this he laboriously pulls water up from the bottom of the well, getting up, perhaps, half a gallon at each lift. With regular troops special water lifting parties will probably be told off, but their method of getting water, and the amount raised per man will be the same.

Watering men and beasts under these conditions is a long business, and often goes on far into the night. It is uneconomical in time as well as in transport, for each man carries his own bucket and rope; but at present no other method exists.

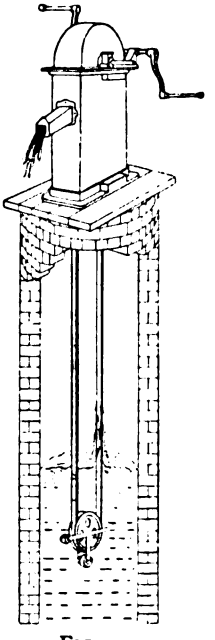

FIG. 5.

Suppose 500 camels have to be watered from one well 150 feet deep by rope and *dilwa*. Each camel wants, say, 10 gallons; therefore, 5,000 gallons are required. Given that each man draws up half a gallon at the time, this means 10,000 lifts. Suppose one man can lift, lower and empty his *dilwa* in one and a half minutes, it would take him 15,000 minutes to water all the camels. Suppose 5 men could work at well-head at once, they would have to work some 50 hours continuously in order to get the work done. Conditions, of course, vary, size of *dilwas*, energy of the men, depth of wells, thirst of camels, etc., but it is fairly clear that by the rope and *dilwa* method the watering of 500 camels is a long business. Given that each camel carries its own rope and *dilwa*, the weight carried by the column will be something like 17,000 lbs., or the useful load of some

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40 camels. Probably one camel in five only would carry rope, so the wasted useful load would be that of eight camels.

It seems that something better could be evolved ; and the Boulton elevator, or something of the kind, appears to fill the bill.

Assuming that man power only is available for getting up the water from the well previously considered. A suitable single hand gear elevator weighs 305 lbs., and works with a belt that weighs 30 lbs. per 100 feet. Three hundred feet of such belt will be required. Say the whole outfit weighs 400 lbs. A single baggage camel will carry this, or it can be loaded on two trotting camels. By making a special elevator gear for the belt to work on, the weight could be reduced by one half ; *e.g.*, aluminium could be used in place of cast iron for the greater part of the well-head fittings.

The elevator could be quickly mounted over the well, and with one man working the handle will bring up 4·4 gallons per minute. By putting 4 men on the elevator, and putting on 3 extra belts, the weight of the outfit will not be more than two camels can carry. The water output will be 17·6 gallons per minute, say, 1,000 gallons per hour, or the whole water could be raised in 5 hours ; the net gain in time being some 45 hours, and in weight the useful load of some 6 camels.

A Chaîne-Hélice elevator, to do the same work as the Boulton elevator, would have to be heavier, the weight of 300 feet of chain being 177 lbs., while 300 feet of the Boulton belt weighs 70 lbs. —the weight of the well-head apparatus being the same in each case. However, the weight is not the most important consideration. The Chaîne-Hélice must have speed, or its output drops ; working with a long, rising chain, heavy with water, men will not keep up chain speed and water will not come up properly.

Suppose motor transport is available, the water supply problem is simplified. A complete power-driven Caruelle plant giving 5,000 gallons per hour from 300 feet is supplied, weighing 1,180 lbs. This is a good load for a Ford van, and could be quickly mounted over any well. The Caruelle belt and the well-head gear that works it has not been designed for military use. It appears, however, to be worth investigation. It is probable that the weight of the whole outfit could be considerably reduced without impairing its efficiency. The jointing of belts is an easy matter, but for military needs some special form of joint might be required.

A further development would be the design of some portable animal-driven well-head gear, to which spare transport animals could be harnessed, and so speed up the rate of raising water without the use of an engine.

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ENGINEER WORK IN CONNECTION WITH THE LANDINGS AT LUDERITZBUCHT AND WALVIS BAY, IN 1914.

(Extracts from "Railway Construction during the campaign of 1914–15, in German South-West Africa," by A. J. Beaton, M. Inst. C.E., C.M.G., V.D., Major, South African Engineer Corps).

Contributed by the Royal Engineer Board.

An advance expeditionary force from the Union of South Africa, under the command of Colonel Beves, landed without opposition at Luderitzbucht on the 19th day of September, 1914, and the main "Southern Force," under the command of General Sir Duncan Mackenzie, C.B., K.C.M.G., V.D., landed on the 4th October, 1914.

Investigations were at once made by the officers of the Engineer Corps to ascertain what plant, materials and appliances were available for the landing of stores, supplies, etc. The main timber pier was found to be intact, but the steam cranes thereon had some of the essential parts missing; these were, however, discovered, and the cranes were put into operation at once. Unfortunately the capacity of the cranes was not sufficient to deal with weights heavier than three tons, consequently other means had to be devised for handling locomotive engines, heavy artillery pieces, condensing plants, boilers, boring machines, etc. Some of the engine packages weighed as much as sixteen tons.

It will, therefore, be seen that the most difficult problem which had to be solved was the best and quickest method of landing the rolling stock and other heavy material which the cranes on the pier were incapable of handling, for on active service quick decision and rapid movement are as essential in engineering problems as in combative actions.

"Military engineering in contrast to civil practice is characterized by makeshifts and temporary expedients," and as there was, therefore, no time nor suitable material available to construct even a semi-permanent landing-stage, a makeshift arrangement had to be contrived out of the best material at hand. It was of vital importance that the heavy artillery and the railway rolling stock should be landed with all possible speed—the one for the coast defence of Luderitzbucht, and the other to permit of an early advance of the railway inland, for the enemy removed the whole of his rolling

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stock to the interior. Furthermore, the early release of the transport ships was important, not alone on account of their costly hire charges, but they were urgently wanted at Cape Town to convey further supplies of ammunition, stores and men from the Union.

After a rapid but careful inspection of the foreshore, it was decided to experiment with a simple inclined plane running into the sea, with a railway connection thence to the station emplacement. The inclined plane or temporary landing-stage which was designated "The Jetty," consisted of piers of loose baulks of timber picked up near the site of the work. The baulks were laid on top of each other to suit the grade, and roughly dogged together, the piers being at about 4-ft. spans.

On top of the transverse baulks or "piers," 10-metre lengths of 3 ft.-6 in. gauge track, consisting of steel sleepers and 40½-lb. rails, were laid, and packed up with wood wedges to secure a uniform grade of 1 in 25. The natural slope of the foreshore was about 1 in 15. "The Jetty" and siding were completed in one day. *Photograph* No. 2 conveys a good idea of the structure.

A pontoon 43 ft. by 25 ft., capable of carrying a 45-ton load, was built by the Engineer Corps in three days from a design prepared by Major Beaton. *Plates* A and B show the plan and elevation of this pontoon. *Photograph* No. 1 shows the launching of this pontoon.

The pontoon had a 3 ft.-6 in. gauge track laid on its deck on which an empty bogie truck was carried from the shore to the ship's side, and heavy cases loaded thereon by the ship's cranes. The pontoon was then towed by a steam tug to the end of "The Jetty," where several closure lengths of track were in readiness to suit different stages of the tide, to bridge any space between the track on the incline with that on the pontoon. After the pontoon was securely fastened to mooring posts, the bogie truck was hauled ashore by a steel wire rope operated by a steam winch at the top of the incline. *Photograph* No. 2 shows the pontoon approaching "The Jetty."

Considerable difficulties, however, were experienced with this scheme, owing to the variation in the levels due to the rise and fall of the tide and from heavy land swells in windy weather, which prevented the fixing of the fish bolts on the "bridging closures."

The first obstacle was overcome by adding to, or reducing, the number of the baulk piers of the incline, dependent on the level of the tide. This was a simple operation, as the timber baulks were floated to or from their position as required.

The second difficulty was obviated by making a longitudinal slot in the web of the junction or closure rail instead of the usual bolt holes. This arrangement not only facilitated the fishing up of the joints, but permitted a certain amount of play to the movements of the pontoon, and relieved the strain on the fish-bolts.

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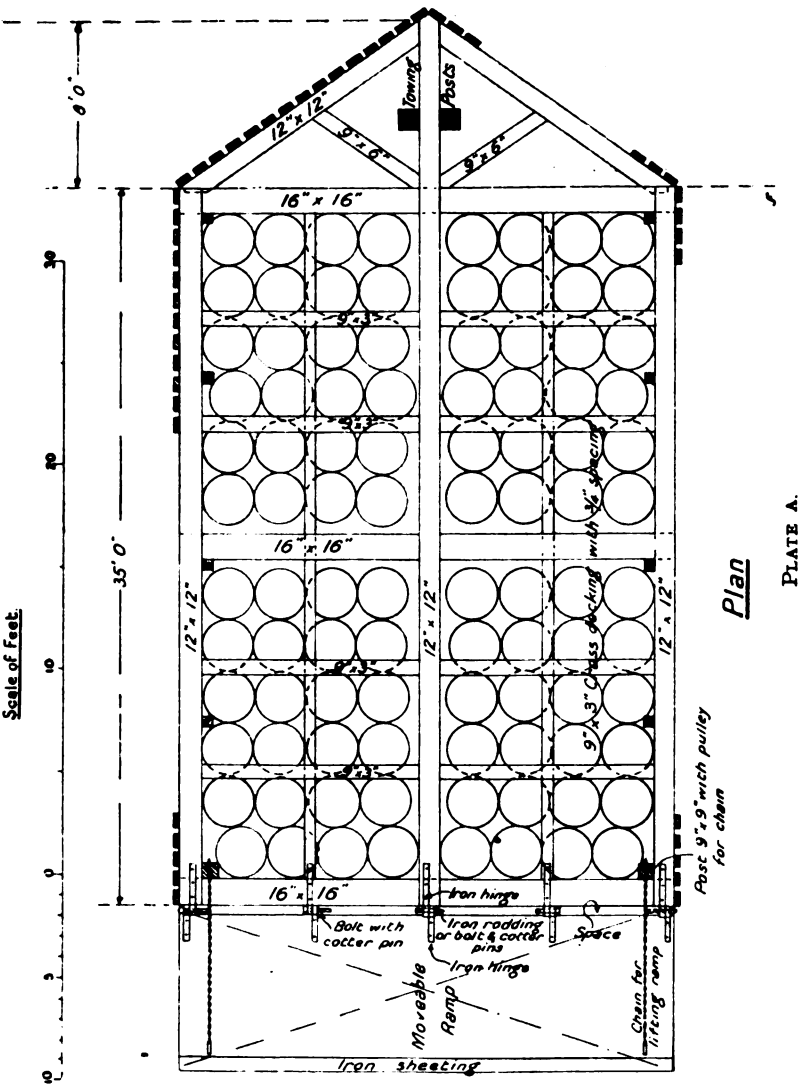

PLATE A.

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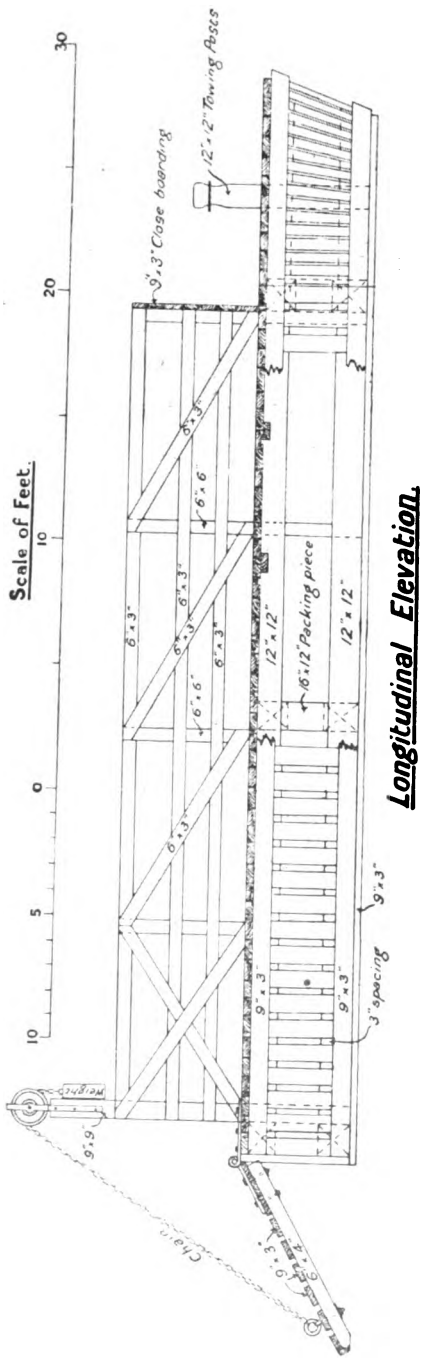
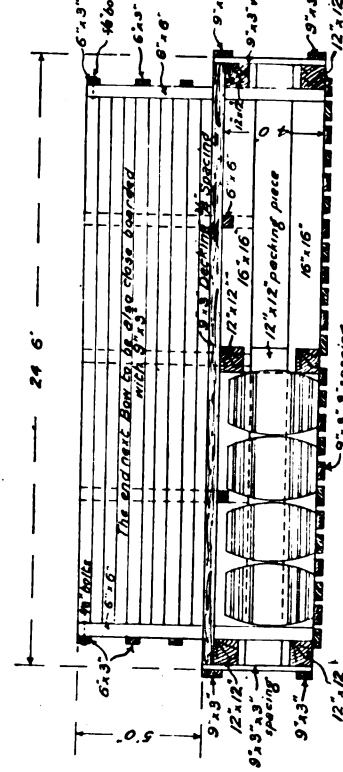


Longitudinal Elevation.



End View.

PLATE B.

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By these simple and somewhat crude means the following rolling stock, etc. were landed during the first ten days of operations, viz. :—

2 Seventh-class engines.
10 Bogie trucks.
3 Ballast trucks.
2 Water tank trucks.
3 Foreshore boilers for condensers.
Several heavy pieces of artillery.

Within fourteen days from the date of the military occupation the engines were landed, erected and in steam, and all the trucks were in running order. There were no railway erecting shops at Luderitzbucht, so that all engine fitting-up had to be done with a makeshift erecting appliance.

At Walvis Bay a similar contrivance for landing rolling stock was adopted, but, instead of a movable jetty as at Luderitzbucht, a semi-permanent pier built of timber piles was used. This method prevented the landing of vehicles at any stage of the tide, as the pontoon had to moor against the end of the pier and discharge its load while the level of the rails on the pier was practically on the same level as the pontoon. *Photograph* No. 3 shows the pier and pontoon at Walvis Bay. The pontoons used here were made at Cape Town and launched from ships.

At Luderitzbucht all rails and sleepers were landed at the main jetty by the steam cranes, but at Walvis Bay, where there were no such appliances, great difficulty was experienced and various schemes tried, but the most successful method was a steam winch and wire rope contrivance erected at high water level, whereby 6 to 8 rails at a time were hauled ashore off the pontoon. Owing to the steep incline of the beach, a timber gallows with a pulley to raise the inclination of the wire rope prevented the nose of the rails ploughing into the sandy, sloping beach.

Steel sleepers were pulled ashore in a similar manner, but all the wood sleepers were thrown overboard from lighters as close to the shore as the craft could float. When the backwash was strong, the sleepers drifted seawards, and natives had often to swim into deep water to recover them. Owing to the variety of sections of rails landed, all the permanent way material had to be classified and sorted on the foreshore before being loaded up on trucks for railhead.

Various other works at the Luderitzbucht harbour were carried out by the Engineer Corps in connection with landing stages for animals and reconstructing the west jetty and gantry whereby weights of ten tons were dealt with from the lighters. The 2-ft. gauge lines on the main pier and traversing the streets and suburbs of Luderitzbucht were of immense value in distributing supplies to the different stores and camps in the town and vicinity.

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Two small locomotives left behind by the enemy in a derelict condition were repaired and did useful work, but the bulk of the traffic was operated by animal traction. Some of the narrow-gauge rolling-stock carried as much as 10,000 lb.

The above extracts give a short account of how the South African Engineer Corps dealt with a contingency which may, perhaps, have to be faced by a future generation.

The works carried out are, in accordance with the dictum of an eminent military engineer :—

" That the fundamental economic principle of military engineering is that time is of essence, and cost and durability of works are ordinarily matters of minor importance. The quickest makeshift is usually the best solution.

" Simplicity must characterize all designs. Materials which are available at or near the site must be utilized to the fullest possible extent. The works resulting from these conditions are of a very simple nature. The highest expression of the skill of the military engineer is this very simplicity and the rapid adaptation of his designs to the tactical requirements of the situation and to the resources in men, tools, materials and time at his disposal."

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ENGINEER WORK IN CONNECTION WITH THE LANDINGS AT LUDERITZBUCHT AND WALVIS BAY, IN 1914.

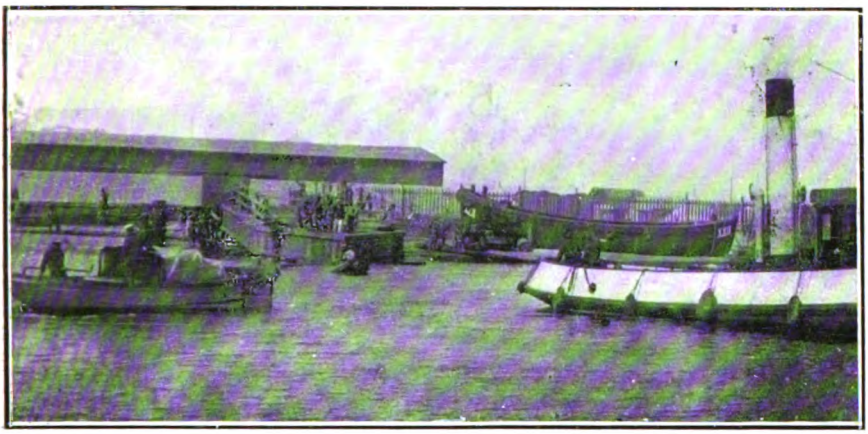

Photo 1.—Launching Pontoon at Luderitzbucht, September, 1914.

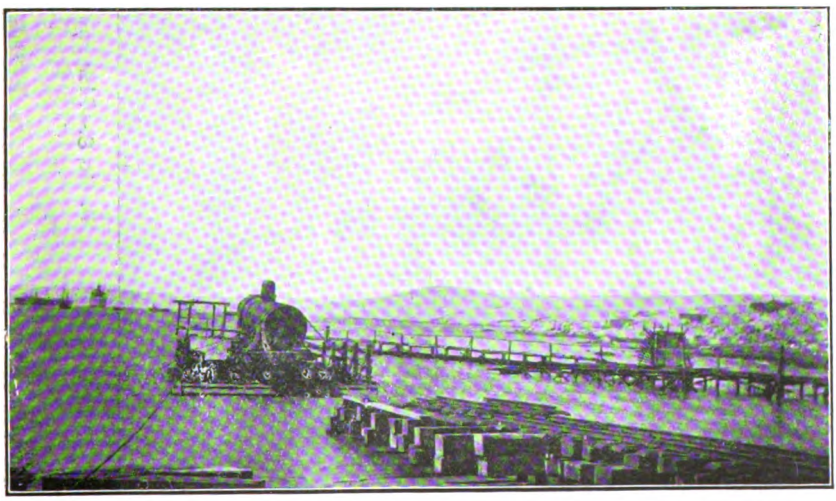

Photo 2.—Pontoon approaching "The Jetty" at Luderitzbucht.

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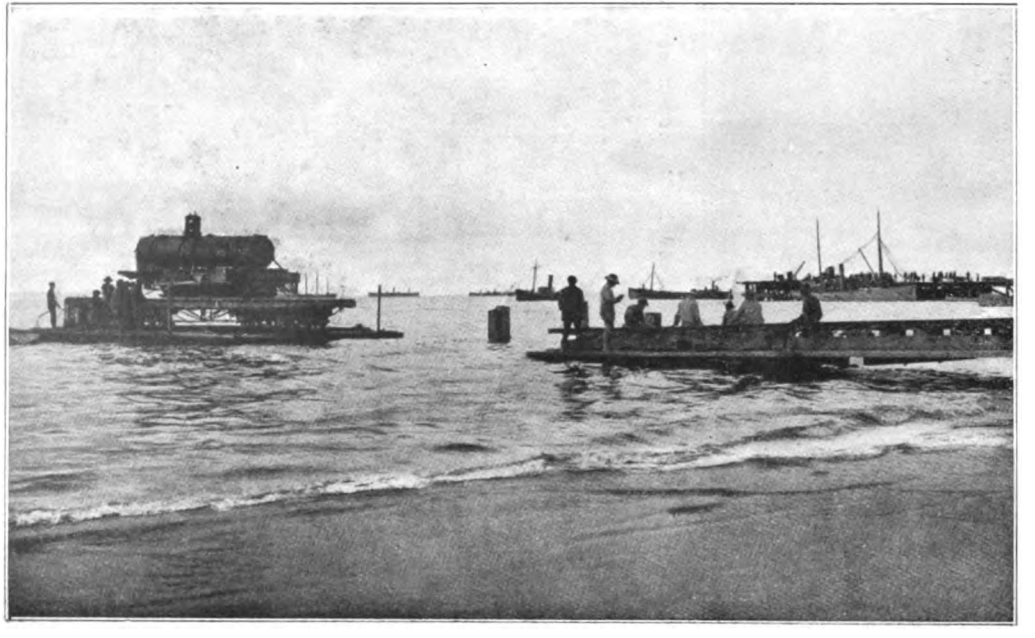

Photo 3.—Pier and Pontoon at Walvis Bay.

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THE TRAINING OF A TERRITORIAL FIELD COMPANY.

By MAJOR H. W. T. PALMER, D.S.O., R.E.

IT is very difficult for a regular soldier, if he has not had practical experience with the Territorial Army, to visualize the circumstances under which a Territorial unit carries out its training. The circumstances are so very different from those which govern a Regular unit that questions of training and administration have often to be approached from a point of view which is entirely new ; and many matters, which in a Regular unit are merely routine, present very real difficulties under Territorial conditions. Like all other difficulties, these exist in order that they may be overcome. But a point which needs emphasis is that, at the present time, the value of any instruction which a Regular soldier may give to members of the Territorial Army will be very greatly enhanced if it be accompanied by sound advice as to how the instruction given can be applied under Territorial conditions. In fact, without this additional information, the instruction given will sometimes fail to reach its objective.

As a result of the late war, the Territorial Army has earned for itself the position which it now holds, and there is now a bond between the Regular and the Territorial Armies which did not exist in pre-war days. It is therefore desirable that the Regular soldier should have an understanding of the Territorial Army, and, when in contact with a Territorial unit in peace time, that he should be able to approach subjects from the Territorial point of view.

This article is written with two purposes in view. Firstly, in the hope that, by dealing with some of the everyday matters which present themselves in a T.A. unit, it may be of use to Regular soldiers who may at any time be called upon to take part in the training of members of the T.A. Secondly, in the hope that some of the methods suggested for overcoming certain difficulties, which methods have all stood the test of practical trial, may be of assistance to Territorial officers in the training of their units.

The conditions affecting Territorial units differ, to a certain extent, according to local considerations. Consequently, in writing an article of this nature, there is always the possibility that experience gained with the engineers of one division on any matter may be based on conditions which do not exist elsewhere. Recently the

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writer had the opportunity of taking part in discussions which were held during a course for senior R.E. officers of the Territorial Army, and in this article he has confined himself to points which were shown to be of general application, and not dependent on a particular set of local circumstances.

I. General Description of Territorial Organization.

The largest formation in the T.A. is the division, and this for training and administration is directly under the Headquarters of the Command in which it is located.

A division is distributed over an area which may vary from a portion of a county to one of several counties. The division is organized on the same lines as a Regular division, but the peace-time staffs of divisional and brigade headquarters are smaller.

With the exception of certain administrative matters, mentioned below, which are dealt with by the County Territorial Association, the unit is both trained and administered by divisional headquarters, working through the usual chain of command.

The Territorial Association of the county in which a unit is located carries out certain administrative duties in connection with all T.A. units in the county. Of these duties the most important are :—

(*a*) Recruiting.
(*b*) Provision of accommodation.
(*c*) Provision of horses.
(*d*) Provision and maintenance of uniform and personal equipment for the men.
(*e*) Provision and maintenance of rifle ranges.
(*f*) Administration of War Office grants in connection with the above as well as furniture, lighting, heating, storemen office expenses, travelling for musketry and annual camp, etc.

The County T.A. Association communicates direct with the War Office, and is not under the Territorial Divisional Commander Consequently, there are two channels of communication between the War Office and the Territorial unit, each dealing with its own class of subjects.

A Territorial unit obtains its arms, unit equipment and training stores from Army sources in the same manner as does a Regular unit.

Funds in connection with the emoluments of the officers and men, as well as allotments from the Training Grant, are obtained from Army sources : the imprest holder being the adjutant.

The location of a Territorial unit varies from the case in which

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two or more units, possibly of different arms of the Service, are accommodated together and share the same drill hall, to that in which the unit is distributed over several stations, and is provided with accommodation at each. Owing to changes, as, for example, the formation of new units and the redistribution of others, that have taken place since the various premises were built, hired, etc., the facilities that are provided at each vary considerably. But the majority of units are well provided with accommodation, which includes drill hall, canteen, recreation room, N.C.O.s' room, officers' room, offices, and stores for clothing, equipment, harness, vehicles, etc., and a miniature range.

Some very fortunate units also possess a drill field, attached to their drill hall.

Officers and other ranks of the T.A. draw pay, rations, or allowances only when at annual camp and courses of instruction, and when taking part in staff rides, regimental exercises or week-end camps.

Out-of-pocket expenses in connection with travelling to drills may be refunded at the discretion of the County Association.

A recruit is eligible to earn a bounty of £2 10s. in the first year of his service by either (*a*) performing 40 drills, firing the musketry course and attending annual training in camp for 15 days, or (*b*) performing 50 drills, firing the musketry course and attending annual training in camp for 8 days.

A trained man can earn a bounty of £3 by either (*a*) performing 20 drills, firing the musketry course and attending annual training in camp for 15 days, or (*b*) performing 30 drills, firing the musketry course and attending annual training in camp for 8 days.

The C.Q.M.S. of a company is paid £50 a year for the performance of his duties, in addition to pay, bounty, etc., mentioned above.

The Territorial officer on the Active List is at all times subject to Military Law. But other ranks are only so subject when actually on parade, when at camp, and when the T.A. is embodied. One important result of the latter provision is that the Territorial N.C.O. or man cannot be compelled to attend a parade. A notification of the parade is given, but it rests entirely with the N.C.O. or man as to whether he attends the parade or not, the one exception to this being the notification to attend annual camp.

The Permanent Staff for Divisional Engineers consists of an adjutant and four (or in the case of wide distribution of units, five) Regular N.C.O.'s, of whom one is from the Mounted Roster. Of these the adjutant and one N.C.O., appointed as R.S.M., alone fill executive posts within the establishment of the Divisional Engineers. In addition to carrying out the normal duties of an adjutant of a unit, the adjutant's chief duty is to assist the C.R.E. with the training of his officers. The R.S.M., in addition to his duties as such, carries out Orderly Room clerical duties, and instructional

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duties as laid down for the remaining N.C.O.'s of the Permanent Staff.

The remaining N.C.O.'s of the Permanent Staff are attached to companies. The details of the attachments vary with the distribution of the companies. These N.C.O.'s do not fill any executive posts within the establishment of the unit to which they are attached. They are placed there as instructors, and their chief duties are :—

(*a*) Instruction of recruits.

(*b*) Instruction of N.C.O.'s in all subjects, and this includes the instruction of the C.Q.M.S., pay-serjeant, etc., in their duties as such.

(*c*) Clerical duties for the O.C. Field Company. The Regulations permit this, provided that it does not interfere with their instructional duties. In actual practice the cases in which the clerical duties have not got to be carried out by the N.C.O. of the P.S., except at annual camp, must be very rare. The duty of pay-serjeant is the one and only duty in a Territorial unit which it is impracticable for the Territorial Army N.C.O. to carry out for himself; except during annual camp, when he can carry it out.

(*d*) The Mounted N.C.O. of the Permanent Staff must carry out all training in equitation, unless the unit is fortunate enough to possess a Territorial N.C.O. who is a qualified equitation instructor.

(*e*) Keeping of AB 220—the book in which attendances at drill, camp, etc., are recorded.

II. Amount of Training Undergone by Members of the T.A.

The amount of training carried out by the Territorial officer is governed by the results which he has got to achieve, and not by the number of periods of attendance at "drills." He has his command to run entirely, both as regards training and administration, and in addition he has to improve his own efficiency. To assist him in the latter respect regimental exercises, staff rides, and lectures are held : and courses are available at the various Army training centres.

As regards other ranks. Recruits are required to attend 40 drills,* and the annual camp, and fire a musketry course during their first year. They are then classified as trained men and as such they are obliged to attend 10 drills in the year and the annual camp and fire a musketry course.

Like the officer, the attendances carried out by a N.C.O. cannot be based on the number of obligatory drills laid down for a trained

* A "drill" consists of one hour's instruction. When larger periods are given, a soldier may count up to a maximum of three drills on any one day.

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man, because he also has his command to run, and to improve his own efficiency by attending special lectures. So, in practice, regular attendance becomes a *sine qua non* for the holding of rank as a N.C.O.

A musketry course is fired annually by all ranks, and attendance at the annual camp for at least eight days is obligatory. The total duration of the annual camp is 15 days, and the majority attend for the whole period.

III. Organization and Administration of the Unit.

This subject is dealt with before consideration is given to the question of training, because it is a branch in which some Territorial units are undoubtedly weak; and if the organization is not sound, the best-intentioned efforts at training will bear little fruit.

The principles governing the organization of the unit are the same as those which apply to a Regular unit, or, for that matter, to any business concern. Three of the chief ones may be summarized as follows:—

(*a*) The number of individuals whom one commander can directly supervise and control is strictly limited.

(*b*) Control must be exercised through a definite chain of command.

(*c*) It is necessary for the commander to direct the policy to be followed by those immediately under him in the chain of command; but, he should leave them scope and initiative as to the methods by which they carry out his policy.

Previous to the late war, many Territorial units were almost entirely run by the Adjutant and the Permanent Staff. The results of this system—or lack of system—were obvious on embodiment.

The object of the commanding officer is to build up a unit, the members of which will all be capable of carrying out their duties on embodiment of the Territorial Army. Now, unless each responsible member carries out his duties in times of peace, he cannot be expected to be able to carry them out when the unit is embodied. This statement may appear to be so obvious as to be superfluous. Nevertheless, the fact remains that it takes continual perseverance on the part of the commanding officer to enforce it because it is difficult to overcome some of the obstacles, and a strong tendency to leave matters to the members of the Permanent Staff is always present. Further, the members of the Permanent Staff are liable themselves, from keenness or other reasons, to carry out duties which belong to members of the Territorial unit. For example, the member of the Permanent Staff finds it much quicker to check a consignment of stores and enter them in the company ledger, than to go and find the Territorial C.Q.M.S. and get him to carry out this duty. But by doing the C.Q.M.S.'s duty for him, the member of the P.S. is defeating his own object in the long run.

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The foundation on which the efficiency of the unit can alone be built is an organization in which each of its members carries out personally the duties which belong to the post which he holds.

The point now to be decided is, what are the duties of the various officers and N.C.O.'s? A suggested distribution of responsibilities and duties as affecting the principal members of company headquarters is given in Appendix A. On the basis that a second-in-command relieves his commander of a considerable amount of the administrative duties, the various duties within a section can similarly be distributed.

In order to be in a position to carry out his duties, an officer or N.C.O. must realize exactly what they are. In order that he may be able to fill his post in the chain, he must have an understanding of the organization of the unit; and in order that he may be in a position to act for his immediate superior, when occasions necessitate, he must have a knowledge of the duties of his immediate superior. It is therefore recommended that the distribution of duties and responsibilities throughout the unit be not only fully explained, but also be put down in black and white, and be kept available for all concerned to have access thereto.

To go a step further, each N.C.O. may with advantage be furnished with a card detailing his duties and responsibilities. This method will convey the lesson much more clearly than the somewhat vague statement that "a N.C.O. is responsible for everything concerning the men under him."

The first stumbling block which a unit commander encounters on attempting to carry out the organization of his unit on the above lines is the absence of persons qualified to carry out the duties of some of the posts in the chain of command. The temptation is to leave the post vacant, in the hope that somebody who has had experience in that nature of capacity will turn up; and, in the meantime, to allow the member of the P.S., or the T.A. C.S.M., or somebody else to carry out these duties, which are not his own. In the writer's experience this is a wrong policy to pursue; and, if the member who is available does not know his job, well, he will never learn younger, and the sooner he starts to learn it the better. He will need very close supervision and guidance for some time to come; but, provided he is keen he will learn; and, when given a show to run, and allowed to run it under *supervision* (which does not mean continual *interference*) it is surprising how quickly improvement comes in what, at first, appeared to be somewhat unpromising material.

With regard to the above, it is not intended to recommend that any N.C.O. be granted rank, above that of unpaid lance-corporal, if he is not qualified for it. The subject of qualification is dealt with later. But it is recommended that each of the necessary posts in

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the Chain of Command be filled by somebody, though the rank of that post cannot be obtained until full qualifications for it are possessed.

The fact remains that the unit has got to be organized as a unit, and the only practical method of facing that proposition is to make the best of the material that is to hand.

Another difficulty in the way of getting the organization into operation is the paucity of occasions on which anything like a full company is on parade. One section may be well represented, whilst another may consist of three or four men, with or without a N.C.O. The error that is liable to be made is to tell these few men to fall in with the section that is fairly strong.

Infantry Training, Vol. I, Section 2, para. 4, lays down very clearly that " To maintain the organization, in and out of battle, no matter what the difficulty, is one of the first duties of every commander," and later, in the same paragraph, states, " So long as one member of a section remains effective, it will retain its identity."

Engineer Training, Section 4 (9) commences with the statement : " Strict and unvarying maintenance of unit *organization* in all circumstances is the surest guarantee of *esprit de corps*."

Every opportunity must be taken for instilling this principle, and the following few examples will illustrate the nature of procedure that is contrary to this principle, but liable to occur unless rigidly prevented :—

(*a*) Member of P.S. ordering the unit to fall in, and generally performing the duties of the C.S.M., instead of the senior T.A. N.C.O. present performing his duty as such, regardless of his rank.

(*b*) If no N.C.O. is present with a section, the roll-call, etc., being carried out by a N.C.O. from another section, instead of the senior sapper present in the section carrying on.

(*c*) Men going direct to the C.Q.M.S. about equipment, etc., without the section or sub-section N.C.O. having any responsibility in the matter.

(*d*) If a man is at fault as regards punctuality, attendance at drills, turn-out, etc., the person in authority, who deals with the case, omitting to take the opportunity of rubbing into the section or sub-section N.C.O. concerned the lesson on his responsibility in the matter.

The above may seem very small points ; but in the T.A. it is only by taking advantage of these small points, and especially of small points of administration, that the organization of the unit can be built up.

As regards the senior and experienced N.C.O.'s, a large proportion of whom may have carried out their duties as N.C.O.'s on Active

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Service. It is sometimes noticeable, particularly in the case of those with pre-war service in the T.A., that, though fully competent to carry out their duties, they are prepared to stand by and allow the member of the P.S. to act for them. This is a relic of the days when it was quite the recognized order of things that the P.S should run everything. This reluctance to assert themselves is not due to any lack of keenness or of self-confidence on the part of the T.A. N.C.O.'s. It may usually be traced to a desire not to intrude on what had come to be considered the functions of the P.S. In the writer's experience the only way to overcome this reluctance was occasionally to prevent the attendance of the member of the P.S., so that the T.A. N.C.O.'s had to carry on. They then did so, and in most cases did so efficiently; thus a start was made in getting those concerned to realize what was expected of them, and that each had an interesting job of his own for which he was entirely responsible. This practice of temporarily removing the member of the P.S. is a valuable method of improving the organization, and consequently the efficiency, of a unit.

An experiment was tried, with noticeably successful results, of removing the members of the P.S. from all companies immediately on arrival at the annual camp. The P.S. were retained at Regimental Headquarters under the Adjutant. If a unit commander required the services of a member of the P.S. for a particular piece of instruction he could obtain his services from the adjutant; but, like a R.E. unit attached to a lower formation than a division, the P.S. instructor returned to the command of the C.R.E. on completion of the particular task.

IV. TRAINING OF THE UNIT.

(*a*). *General.*

The salient points governing training in a Territorial unit are the shortness of the time available for instruction during the year, and the impossibility of getting regular attendance of all the members of a class throughout the sequence of any course arranged.

As regards the first, the Territorial soldier has to be taught in minutes what the Regular is taught in hours. Therefore, the Territorial officer must think in minutes when supervising the training of his command. Every minute is of importance. It is necessary to prevent even the shortest delays during parade hours. Five minutes spent in drawing stores, which with foresight might have been laid out in advance, is valuable time wasted. Men left standing about and learning nothing, whilst awaiting their turn to shoot on the miniature range, is another example of time being thrown away. Further, as the time is so short the instruction has got to be carefully prepared in advance so that the man is only taught just what is essential for the object in view. A case which comes to mind, as an

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example of time being wasted, was an occasion on which the writer heard a squad being taught about the weight of the rifle, number of grooves in the barrel, and a number of other facts, which were interesting but of no practical use for attaining the object in view; the latter being to teach the men to be able to hit a target, with only a very few "drills" available in which to teach them. The importance is obvious of a squad or class working "all out" throughout the whole of a period of instruction. But it must be realized that every instructor is not blessed with the ability to keep a class interested and working at pressure for a whole hour at a stretch. Consequently, it is recommended that, as a rule, instruction should be given in two or more different subjects during each "drill."

As regards the loss of the sequence of instruction during a course, owing to members of the class missing lectures or parades, in a unit in which soldiering is not its members' primary occupation, unavoidable cases of absence must occur, and must be accepted as a necessary evil. If, however, avoidable cases of absence are frequent, the cause will lie in the nature of the instruction given. the recreational facilities provided or the state of the organization of the unit. It is recommended that the remedy be applied in the direction of improving these, rather than on the lines that the absentees are solely to blame.

The subjects that have to be taught in a field company are laid down by the Army Council. They cannot all be even touched upon during any one year; but the selection of the subjects for the year, and the ground to be covered in each, will have been decided upon by the C.R.E. and so this question need not be discussed in this article.

(*b*). *Training of Officers.*

The time which the officers can devote to military duty is strictly limited in a R.E. unit, where it is the exception to find an officer who is not a busy professional man. Of this time, a very considerable portion is occupied in the administering and training of their commands. Although an officer undoubtedly "learns by teaching those under him," still, what he learns in this manner only covers a very small portion of the ground which he must cover to keep himself up to the standard demanded by his rank. In addition to the subjects that have to be taught to those under him, he must possess knowledge which will enable him to adapt his professional knowledge to military requirements: and, in order that he may have a knowledge of what the military requirements are in any situation, he must have a knowledge of the functions and methods of employment of all arms. The contents of *Field Service Regulations* is therefore necessary, in addition to that of *Engineer Training* and the engineering manuals.

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How to acquire this knowledge with limited time is a problem, for which a solution has to be found.

There are practical considerations, of which human nature is one, which will render unsuccessful the solution of merely relying on all the officers of a unit devoting their hours of recreation to a frequent study of these manuals. Regimental staff rides, and courses at the S.M.E., or with Regular units, for those who can give the time for them, are valuable aids. Courses of lectures by the adjutant will only partially solve the problem, owing to difficulty in the way of all officers being able to attend on the same night. In the case of divisional engineers, the units of which are distributed over several stations, it becomes all the more unlikely that it will be practicable to achieve anything approaching the result desired by means of lectures.

The solution would appear to lie in supplementing lectures and staff rides by some means whereby all officers will carry out an organized course of instruction in their own homes and at times convenient to themselves. But some form of test or proof of action taken is a necessity to keep the system working : for good resolutions are apt sometimes to fail in the carrying out.

A system on these lines, which was adopted by the Engineers of one division, was a weekly correspondence course carried out by the adjutant with each officer. It did not entail a heavy task upon anyone, and its results were satisfactory. All the officers agreed that one hour in the week was the period which they could undertake to devote to this course ; and the weekly programmes of study were adapted accordingly. The system was that, at the end of the week, each officer was notified of the pages of *F.S.R., Engineer Training*, or of an engineering manual for study during the ensuing week, and he was given a short series of questions bringing out the application of the contents of these pages. During the ensuing week he posted his solutions to these questions to the adjutant. At the end of this week the adjutant sent to him a copy of the suggested solutions to the last questions, and a notification of the subject for the next week, together with the questions thereon. Criticism and comments on officers' solutions were only sent in special cases. Even on those occasions when it was impracticable for an officer to devote the time necessary for that week's subject, it was agreed that useful instruction was obtained by noting the adjutant's suggested solutions to the problems.

(*c*). *Training of N.C.O.'s.*

Training presents little difficulty in the case of the efficient and experienced N.C.O.'s. They can keep themselves efficient by teaching those under them, and in addition special lectures can be arranged. But the training of N C.O.'s who have had no previous

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experience in the Corps, or who have had very little training of any nature, is a very different matter. By being given practice in taking command of, and in carrying out administrative duties in connection with their own men, their ability to take charge and to accept responsibility will develop. But when it is a question of these N.C.O.'s teaching drill, musketry or fieldworks, the difficulty is to teach them sufficient to enable them to carry on tolerably well on the next parade, without even attempting to look further ahead.

Special classes for these N.C.O.'s must be held, and the instruction of these classes must take place at a time when the sappers and drivers are not parading. The practice, on a parade night, of the bulk of the N.C.O.'s being taken away for lecture, whilst the sappers or drivers are collected together for instruction under a member of the P.S. or some senior N.C.O. is fundamentally wrong: for it is detrimental to the building up of the organization of the unit.

It is usually necessary that the instruction of the N.C.O.'s class on any one evening should be based on what they will have to teach their men on the next parade. It must also be remembered that not only has subject matter to be taught, but also instruction must be given as to how to teach it to their own men.

The preparation of the lecture or other form of instruction to be given to a N.C.O.'s class has therefore got to be made with care and thoroughness, for the instructor is very liable to neglect the second object in view.

Although keenness and interesting instruction will in most cases produce regular attendance at the N.C.O.'s classes, an incentive is added by the provision of a definite object at which they can aim. The system of holding oral and practical examinations for promotion, say half-yearly, and a rigid adherence to the principle of never considering a N.C.O. for promotion unless he has passed the examination held for his rank, will provide an object.

Another point in favour of these periodical promotion examinations is that they provide a means whereby merit can be rewarded. A soldier of previous experience as a N.C.O. may enlist at any time. His capacity may be such that he would be valuable to the unit as a senior N.C.O. forthwith. But it is liable to dishearten those who have been serving in the unit for the past three years if a new arrival is immediately promoted over their heads, on his past record in some other unit. But the institution of the periodical promotion examination introduces a means whereby each can definitely establish his merits in competition with the other candidates; and nobody can then cavil at the reward going to the best.

It is particularly trying for a senior, whether officer or N.C.O., to stand by whilst an inexperienced junior is making a well-intentioned but somewhat feeble effort at instructing his men. The knowledge that he could carry out the instruction so much more

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efficiently himself, affords a strong temptation to the senior to take the job out of the junior's hands. But the fact remains that the training of the officers and N.C.O.'s is of first importance: and, unless the junior is given his chance, he will never learn. Therefore, if the senior is forced to intervene, his action should be in the direction of assisting the junior to carry on; and not on the lines of doing his job for him.

Regimental exercises for N.C.O.'s form a valuable means of instruction. But, in the writer's experience, any attempt at carrying out instruction of both officers and N.C.O.'s at the same exercise on the same day is not a success. In theory it would appear sound that first the officer should carry out his portion and then he should allot tasks to his N.C.O.'s; but in practice various circumstances affect the case, with the result that neither class gets sufficient value in instruction for the time available.

(*d*) *Training of Sappers.*

The salient difficulties here are the unevenness of the standard within the section, and the difficulty in giving practical instruction in fieldworks at the drill shed.

The unevenness of standard will not apply to a great extent as regards fieldworks, for the percentage of men with previous service in the Corps, who will not have attained to non-commissioned rank, will be small. But for instruction in drill and musketry, the standard will vary from the man who has had several years of previous service in the infantry, to the man whose experience of soldiering is limited to his recently completed recruit drills.

It is in the interests of the unit that the attendances of those men who are at least moderately proficient at drill and musketry, should be concentrated on those parades at which instruction in fieldworks is being given. But it means a very persevering effort, on the part of all in authority, to procure attendance at just those parades which are most beneficial to the sapper concerned. Unless this effort is made and maintained, the attendance at "drill" will be haphazard, and individuals will be left to turn up at the drill hall and "find out what is on when they get there." The effect on the keenness of a man with years of service in the infantry, who finds out four or five times running that it is "squad drill and rifle exercises" is obvious.

In order to procure attendance on anything approaching a system, the responsibility for the attendance of his men should be placed upon the Territorial section—or better still, sub-section—N.C.O. Apart from the question of organization, which has already been discussed, his persuasive efforts will probably be more successful than postcards or other notification sent direct from company headquarters to the individual sapper. As soon as a N.C.O. has

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really begun to " get hold of " his command, his efforts will certainly be the more successful method.

Another necessity in this connection is the early publication of the training programme. One thing which cannot be done in the T.A. is to make arrangements for *anything* at short notice : and the publication of the details of periods of instruction a week or a fortnight in advance does not give sufficient notice to enable those in subordinate positions of authority to act. A system, which in one unit has provided a means towards arranging attendances on a system, and gives sufficiently early notification to all concerned, is the issue to each member of the unit, at the beginning of each quarter, of a linen-backed folding card, on which are printed the details of all parades for the ensuing quarter, the names of the instructors in special cases, and the paragraphs of the manuals that will be dealt with on each parade. These cards have the advantage over the publication of parades in local newspapers, in that they are convenient for a man to retain in his pocket ; the parades at which his attendance is particularly required can be marked for him, and he will have the information definitely written down and in his possession, instead of reliance having to be placed on his remembering what he was told or what he saw in the evening paper, if he read it.

Further advantages of this card system are : (*a*) that keen N.C.O.'s have a means of knowing beforehand the exact details of what they will be called upon to teach, and (*b*) that the cost in the case quoted was less than that of the system of newspaper publication.

As regards the difficulty of giving practical instruction in certain branches of fieldworks at a drill hall, to which no ground out of doors is attached : The chief cases in point are entrenching, obstacles and bridging. Useful instruction in pontoon drill and the construction of footbridges of petrol-cans, cork-floats, etc., is possible. But beyond that, it would appear that the difficulty must be overcome by the use of fairly large scale models. Valuable instruction can be given with models in preparation for the carrying out of actual work at camp : and the possession of adequate models would appear to be a necessity for the instruction of a unit.

It is obviously desirable to obtain attendances at drills in excess of the number which has a bearing on the amount of bounty earned. In a certain unit a stimulus was given to this by the formation of a class for those sappers who wished to compete at the next examination for appointment as lance-corporal. The attendance at this class was very satisfactory.

(*e*) *Training of Drivers.*

Training in actual driving has mainly to be carried out at the annual camp : but the facilities for teaching riding and all preliminary

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work are good in most towns. Although external courses do not exist for the sappers (and it is doubtful if the expenditure on their institution would sufficiently benefit the unit), great benefit can be obtained by the attendance of drivers for a short course at the R.E. Mounted Depôt, Aldershot.

V. CERTAIN DIRECTIONS IN WHICH THE ADJUTANT CAN ASSIST.

(*a*) Owing to the limited amount of time available for their military duties, it becomes of the greatest importance that the unit commander and his officers should be able to devote every possible minute of their time spent at the drill hall to actions which will assist directly to further the efficiency of themselves or their commands. In exercising the command of a unit there is bound to be an amount of correspondence. But, if a means can be devised whereby the adjutant can reduce the time spent by officers on office work, the unit will benefit. The sort of actions which consume time without furthering efficiency are the reading through of a monthly book of Army Orders or Army Council Instructions, only to find that there is nothing contained in them which affects the unit; the reading through of a very lengthy A.C.I., when the only portion which can affect the unit is contained in a small paragraph hidden away in the middle; the necessity of having to read through a lengthy instruction several times to make sure that the meaning is grasped correctly, and then having to write to the C.R.E. to ascertain whether it applies or not. To the Regular soldier these would appear to be trivial matters, and all in the day's work. But to the Territorial unit commander, who rarely possesses a fully-qualified orderly room clerk, it is a very different matter, and constitutes a drag on the training of the unit.

The Regimental orders issued by the C.R.E. can be utilized in such a way as to provide a labour-saving device for the company commanders, with regard to such matters as those cited above. It is a simple matter for the adjutant to incorporate in orders a very brief *précis* conveying the gist of *all* instructions and information received from Higher Authority, which can in any way affect any members of the companies. By mention being included of the reference of the source of information, the unit commander is enabled to refer at any time to the more detailed instructions, if necessity arises; and, by having the matter mentioned in his file of C.R.E.'s orders, he has a ready means to hand of tracing the source of information he requires, if the need occurs at some later date.

A considerable amount of time spent in registering, filing, and in office routine generally can be saved in the company offices by adherence at Regimental Headquarters to the principle of never writing about anything if it can possibly be communicated by means of the Regimental Orders

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It is difficult for a unit commander to read through all A.O.'s, A.C.I.'s, etc., but it is quite impracticable for junior officers to do so. But another advantage of the system of publishing everything through Regimental Orders in *précis* form is that the perusal of the file of C.R.E.'s orders furnishes a rapid means whereby all officers can keep themselves acquainted with any information, changes, etc., which may affect themselves or their commands, either as regards training or administration. The simple rule that this file has to be initialled up to date by officers will save the unit commander many written communications.

In order to save the clerical work involved in repetition in company orders, each unit should receive sufficient copies of C.R.E.'s orders to enable a copy to be posted up in every drill hall.

Any additional labour involved in the C.R.E.'s office by the above procedure is amply repaid.

(*b*) There are certain stock lectures which a Territorial subaltern is called upon to deliver from time to time, such as lectures on discipline, map-reading, reconnaissance and report writing, etc. The material for these is laid down in various manuals, but all Territorial officers will be able to remember occasions when they have arrived at the drill hall to give a lecture, to the preparation of which they have been quite unable to devote time beforehand. As regards fieldworks and co-operation with other arms, this is not of so much importance, as the course which they themselves are undergoing with the adjutant covers these subjects. But as regards subjects such as map-reading, etc., there may be no recent experience on which they can frame their lecture; and the result is that the lecture given is not as instructive as it otherwise might have been. Cases also occur when a substitute has to be detailed at very short notice to give a lecture.

The adjutant can be of great assistance to all concerned, and incidentally he can facilitate a uniform standard of instruction in the subjects throughout the units, by writing out these stock lectures, either in full or in the form of headings and notes, and by issuing a copy for each drill hall. These can then be kept filed together ready for reference if required.

(*c*) Every unit is not fortunate enough to possess a fully-trained and experienced C.Q.M.S., and it must be the exception at present for a unit to be furnished with a Permanent Staff instructor whose experience in these duties extends beyond what he has managed to learn during his present employment. The result of such a combination is additional correspondence, and possibly a deficiency of stores. The correct procedure for all branches of the C.Q.M.S.'s duties is no doubt laid down explicitly somewhere; but it is sometimes a matter of much time and labour to find just the information required. Further, there are various necessary steps to be taken

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which an efficient C.Q.M.S. always knows from experience, and the neglect of which may involve his commanding officer in financial liability, *e.g.*, the danger of giving a clear receipt to the railway company previous to checking contents, and suchlike. The adjutant can be of material help to a unit by preparing, in conjunction with a quartermaster of experience, very clear and definite notes on the procedure in connection with the various duties of a C.Q.M.S. Suggested headings under which these notes might be compiled are :

1. Public Equipment.
2. T.A. Association Equipment.
3. Clothing.
4. Transport of Stores.
5. Ammunition and Explosives.
6. Supplies.
7. Camp Equipment.
8. T.A. Association Property.

(*d*) The case of the pay-corporal is analogous to that of the C.Q.M.S., except that in all probability he will only be able to carry out his duties at the annual camp. The chances are very remote that the member of the P.S., who normally has to carry out the clerical work, is fully trained in pay duties. A short cut to knowledge of office routine is therefore almost a necessity. The following headings are suggested for guiding notes :—

1. System of filing, and dealing with correspondence.
2. Method of obtaining books, stationery, etc.
3. Stock of books, forms, etc.
4. Books, registers, etc., to be kept posted up to date.
5. Part II orders.
6. List of files of orders, etc., to be kept up to date.
7. Payments from Army funds.
8. Cost accounting.
9. Training grant.
10. Hire of horses.
11. Association funds, and dealings with the T.A.A.
12. O. i/c R.E. Records.

In conclusion, mention must be made of one outstanding feature which, if it be possible, holds increased importance in a Territorial unit. That is, that Energy and Enthusiasm on the part of anyone in authority are very infectious : and in a Territorial unit furnish the sole means whereby the best results can be obtained from any arrangements made for organization or training.

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APPENDIX A.

Suggested distribution of duties amongst the principal personnel of Company Headquarters.

1. UNIT COMMANDER.

(*a*) Dictates general policy and supervises the work of his immediate juniors.
(*b*) Training of officers.
(*c*) Issues Training programme.
(*d*) Such cash accounts as he retains under his own hand.
(*e*) President of Sports and Entertainment Committee.
(*f*) Secret and confidential files.
(*g*) Confidential Reports.
(*h*) Promotions.
(*i*) Sees all correspondence arriving at his unit and signs all correspondence leaving his unit.

2. SECOND-IN-COMMAND.

All administrative duties. These fall under the following headings:—
(*a*) Discipline.
(*b*) Training of officers in administrative duties: and responsibility for seeing that administrative duties are carried out efficiently in each section.
(*c*) Travelling arrangements and warrants.
(*d*) Such cash accounts as the O.C. allots.
(*e*) A.B. 220 (which is kept by the member of the Permanent Staff).
(*f*) Men's documents and Part II Orders.
(*g*) Publication of administrative orders in company orders.
(*h*) Trade testing.
(*i*) Accounting for maps, books, etc.
(*j*) Addresses of personnel.
(*k*) Efficiency of wheelers, saddlers, shoeing smiths, cooks, sanitary squad.
(*l*) Medical arrangements, including reports under T.A. Regs. para. 659 A.
(*m*) Veterinary and shoeing.
(*n*) Supply of horses.
(*o*) Equipment.
(*p*) Supplies.
(*q*) Clothing.
(*r*) Bedding.
(*s*) Accommodation.
(*t*) Camp equipment.
(*u*) Ammunition and explosives.
(*v*) Custody of arms.
(*w*) Repair of arms.
(*x*) Vehicles.
(*y*) Provision of Transport.
(*z*) Engineering stores.
(*aa*) All T.A. property.

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In addition to his administrative duties he commands the personnel of company headquarters, and his duties in this respect are as laid down for a Section Commander.

3. COMPANY SERJEANT-MAJOR.

For any duties in connection with Training, he works directly under the O.C. Company, for whom he prepares Company Orders for signature, and for the publication of which to all concerned he is responsible to the O.C.

The bulk of his duties, however, are administrative, and for these he is responsible to the Second-in-Command. These all come under the headings (*a*), (*c*), (*g*), (*j*), (*k*) and (*l*) as laid down for the Second-in-Command. In dealings with N.C.O.'s and men he will, to the utmost extent practicable, do so through their Section Commander or Section Serjeant. In addition to his duties as C.S.M. to the Company, he carries out for the personnel of Company Headquarters the duties as laid down for a Section Serjeant.

4. COMPANY QUARTERMASTER-SERJEANT.

He is directly responsible to the Second-in-Command for duties (*o*) to (*aa*) as laid down for the Second-in-Command.

He will keep a table showing all returns due from his department and is responsible that these are rendered punctually.

In dealings with sections, his military knowledge will decide him as to whether to deal direct with the Section Serjeant or with the Section Commander on any point; but whenever the acceptance of financial responsibility by the Section Commander is involved in the transaction, he will deal with the Section Commander.

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CIMENT FONDU.

By CAPT. J. C. P. TOSH, M.C., R.E.

"*CIMENT FONDU*" or Fuzed Cement, was originally invented in 1905 by M. Bied, then engineer to the firm of Pavin de Lafarge at Tiel, which has since developed its manufacture on a commercial scale.

The new material possesses many advantages over Portland cement and represents an entirely new departure in cement manufacture. Briefly, *Ciment Fondu* dévelops in 48 hours a strength approximating to that of Portland cement at the end of 28 days, while at the same time its rate of setting is considerably slower. It is further claimed that the strength of *Ciment Fondu* concrete at three months is double that of Portland cement concrete. At the outset, therefore, it will be seen that the use of *Ciment Fondu* should effect considerable economies both in shuttering and in the size of concrete members, and that concrete structures made with it can be taken into use much sooner than is possible where Portland cement is employed. *Ciment Fondu* has the further advantage that it will resist the action of sulphates; it has been tested with sand containing up to 50 per cent. of crushed sulphuric anhydrite, and found to be practically unaffected.

Ciment Fondu is an alumina cement, that is to say, it depends for its cementitious properties on aluminates of calcium. Portland cement, on the other hand, is principally a silicate cement. The following table shows the approximate composition of the two cements:—

Constituents.	Ciment Fondu.	Portland Cement.
Silica (SiO_2)	10—12	20—24
Alumina (Al_2O_3)	40—45	6—8
Iron	10	2—4
Lime (CaO)	35—40	60—65

Now, the combination of alumina and calcium takes place at a much higher temperature than the combination of silica and calcium. Hence a much higher temperature is required for the production

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of *Ciment Fondu* than for Portland cement. The former is liquified at a temperature of 2732° Fahr., while the latter is clinkered at 1832° Fahr.

A high alumina content in Portland cement produces a very rapid rate of setting; it might, therefore, be expected that *Ciment Fondu* would be extremely quick setting. This, however, is not the case, because the high rate of setting only occurs when the aluminates and silicates of calcium are both present. It is, therefore, essential that only a very small proportion of silica be present in the furnace, otherwise Portland cement will be formed as an impurity and the product will be too quick setting to be of any practical use. The raw materials must accordingly be most carefully selected; at Tiel only limestone and bauxite are used, the latter being an ore of aluminium containing chiefly aluminium hydroxide and iron hydroxide. Setting time is regulated by hydration during manufacture so that the time of initial set is about two hours, after which the cement sets very rapidly. No free lime is formed in setting.

Owing to the high temperature required in manufacture and the special raw materials used, the price of *Ciment Fondu* in France is twice that of Portland cement, but despite this handicap it is making its way in civil engineering owing to its special qualities.

Some interesting statements regarding *Ciment Fondu* were made at the International Railway Congress held at Rome in April, 1922, by various French Railway Engineers. M. Séjourner, Algerian Section of the P.L.M. Railway, after some experiments made in 1916, purchased the whole output of the Tiel Works for some time. It was stated that *Ciment Fondu* had been successfully used on the Nice–Coni line in situations where, owing to the presence of water containing sulphates, ordinary Portland cement had disintegrated.

In the case of a tunnel under repair on the line from Mantes to Caen, all the exposed portions of the mortar had been attacked by locomotive smoke; *Ciment Fondu* was applied and so far has been quite resistant.

Piles made with *Ciment Fondu* in reinforced concrete have been driven when three days old. It was found that the adhesion of steel in *Ciment Fondu* concrete was greater than in Portland cement concrete.

The final summary made by the President of the Railway Congress with regard to *Ciment Fondu* ran as follows:—

"It would be interesting to follow the result of the use of *Ciment Fondu*, which should prove of distinct value in several classes of work, and which appears to offer exceptional resistance to the deleterious effect of salt-water consequent on the presence of sulphate of magnesia."

It has also been used extensively in France for marine work, bridges, roads, and so on. Two balconies at the newly-constructed

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Mathurins Theatre in Paris were made in *Ciment Fondu* and all shuttering and supports were removed in 48 hours. Towards the end of the war, *Ciment Fondu* was used for gun positions during the pursuit, platforms for the heaviest field pieces being used three days after laying.

In view of these interesting reports which had appeared from time to time in the technical Press, it was decided to try to obtain some of this material in order to carry out tests at the S.M.E., and correspondence was opened with the firm of Lafarge at Marseilles. The latter very generously supplied a barrel of *Ciment Fondu* for the purpose, and experiments were started early this year.

First of all, the series of tests laid down in the British Standard Specifications for Portland cement were applied, in order to get some comparison between the two. The tests were carried out in very cold weather and the correct temperature for curing specimens could not be maintained. The early results of tensile tests may, therefore, be considered as erring on the low side.

The tests carried out were as follows :—

(*a*) *Fineness.*—Standard sieves were employed and the residues obtained were as follows :

on 76×76 sieve ... ·5%
,, 180×180 ,, ... 8·9%

For comparison, the figures laid down in British Standard Specifications are 1 per cent. and 14 per cent.

(*b*) *Tensile Tests.*—The results obtained are shown by curves on diagram " A," the values given being the mean of five briquettes broken at each age.

Another small series of tests was made, starting on May 12th, in order to determine the effect of storage. The cement had been stored in a somewhat damp shed in its original barrel, open at the top, for about two months. The values given are the average for three briquettes of each age ; the curves for these are shown chain dotted. The inference is that, allowing for the expected earlier gain in strength due to warmer weather, no deterioration had taken place.

The strengths laid down in B.S.S. are as follows :—

	7-day	28-day
Neat cement	... 450	... 540 lbs. per sq. in.
1 : 3 mortar	... 200	... 250 ,, ,, ,, ,,

But all good brands of Portland cement give much greater strengths than these, and a fairer average strength for comparison may be taken as :—

	7-day	28-day
Neat cement	... 580	... 800
1 : 3 mortar	... 290	... 340

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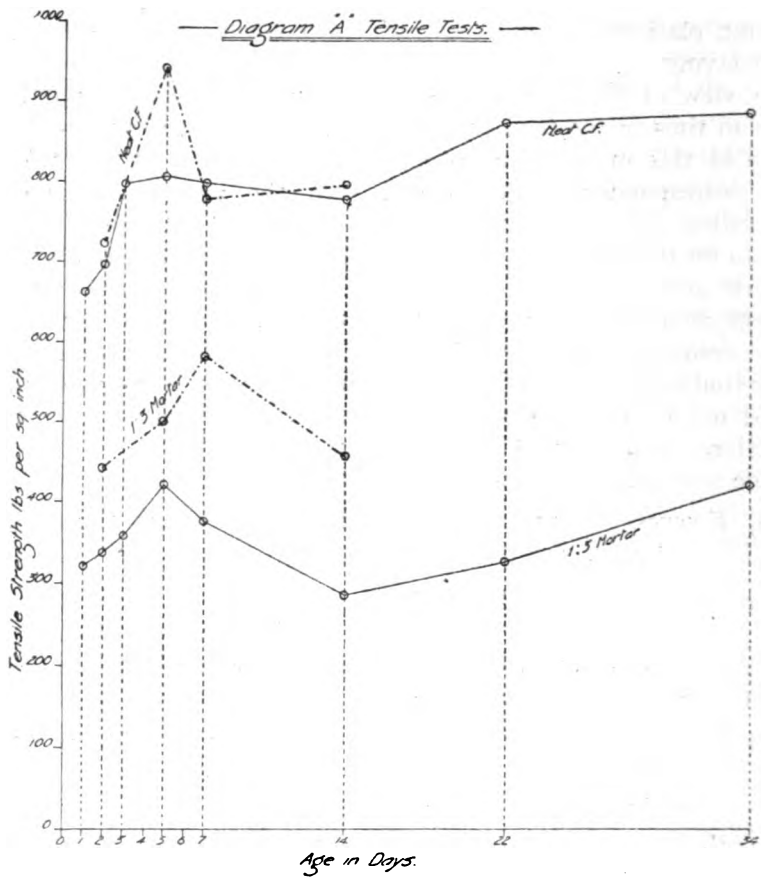

Age in Days	Neat C.F. lbs per sq inch		C.F. Mortar 1:3 lbs per sq inch	
	March Tests	May Tests	March Tests	May Tests
1	662		320	
2	696	721	358	442
3	798		358	
5	805	940	420	500
7	798	776	375	581
14	776	795	285	455
22	872		325	
34	895		420	

Curves representing tests carried out in May are shown - - - - - -

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The drop in strength at an age of 7–14 days need not be regarded very seriously, since it is a common phenomenon in the testing of all small tensile briquettes and does not indicate a corresponding drop in crushing strength.

The tests carried out in warm weather show much greater strengths, especially in the case of the mortar briquettes ; this is to be expected since the neat cement, in setting, gives a considerable rise in temperature, which would, to a certain extent, counterbalance the coldness of the atmosphere.

A curious phenomenon observed during these tests was the formation of an insoluble powdery scum on the specimens during setting. It was particularly noticeable on the neat *Ciment Fondu* briquettes. On inquiry, the manufacturers stated that this scum or film consists of alumina released during setting, and it is for this reason that they emphasize the necessity for carefully cleaning the surface of old concrete before adding new.

Diagram " B " shows the results of tensile tests carried out by Mr. Herbert J. Davey, M.INST.STRUCL.E., who kindly consented to their inclusion in this article. The high strengths obtained at the age of one or two days should be particularly noted, illustrating, as they do, the unique advantage of the new cement.

Setting Time.—The following average setting times were obtained, using the Standard Vicat Needle :—

Initial setting time	...	2 hrs. 50 mins.
Final setting time	...	4 hrs. 25 mins.

Setting time tests were also made in the middle of May to see what effect any storage, under the conditions mentioned before, had made. The results were :—

Initial setting time	...	1 hr. 55 mins.
Final setting time	...	3 hrs. 5 mins.

The inference is that the more rapid set was due to the warmer weather and that storage had not slowed down the rate of setting.

Soundness.—The Le Chatelier Test showed no measurable expansion after six hours' boiling, the British Standard Specification allows an expansion of 10 mm.

In addition, the " Hot Pat " test was carried out, which is probably more exacting than the Le Chatelier test. The pat showed no signs of cracking or warping after boiling for three hours.

N.B.—In all tests, the standard proportion of water was used in gauging, *i.e.*, 22·5 per cent. by weight for neat *Ciment Fondu* and 8 per cent. for 1 : 3 mortar, using standard sand.

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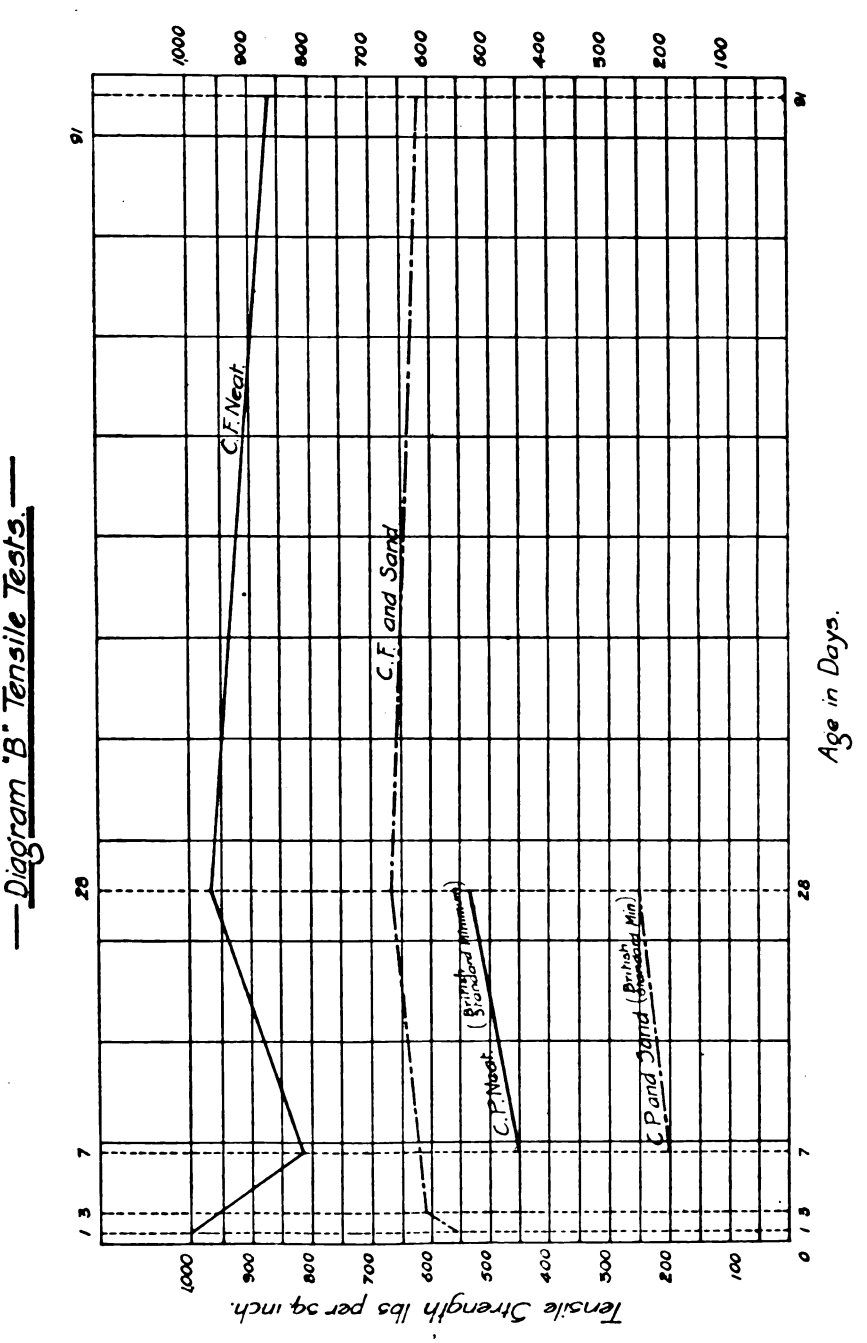

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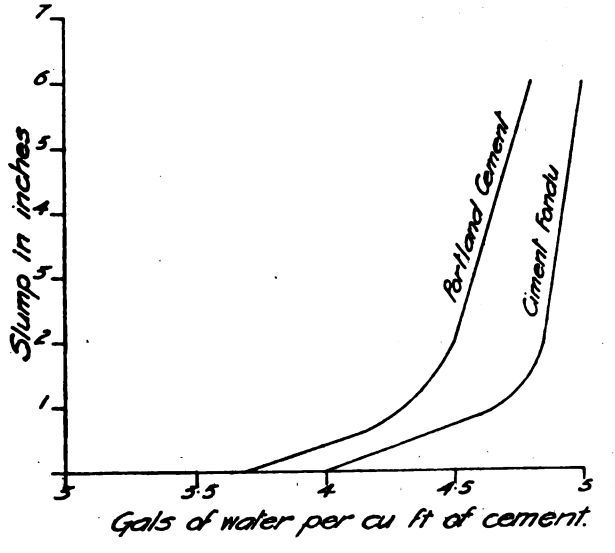
Tests on Concrete.

Slump Tests for Consistency.—Comparative tests on 1 : 2 : 4 concrete mixtures of Portland cement and *Ciment Fondu* were made, the results being given on Diagram " C."

The curves show that the *Ciment Fondu* concrete mixture behaved in exactly the same way as Portland cement concrete, but required slightly more water to produce the same consistencies.

Strength and Hardness Test.—A rough field test for comparing the resistance to explosive force of Portland cement and *Ciment Fondu* concrete was devised and carried out. Blocks of 1 : 2 : 4 concrete, measuring 1 ft. × 1 ft. × 6 in., and reinforced with one layer of X.P.M. at the middle, were made and tested at various ages by firing,

Diagram "C" Slump Tests.



in the centre of the upper surface, a charge of two 1-oz. primers of dry guncotton tamped with sandbags.

It is not claimed that any very accurate comparison could thus be made, nor that any definite inferences as to the resistance of *Ciment Fondu* concrete to explosives could be drawn, as it was impossible to secure uniform conditions of bedding, contact and tamping.

The *Ciment Fondu* blocks were tested at ages of 3, 5 and 7 days, the result being a small crater in the centre, a few radiating cracks and spalling round the upper edges. The five-day blocks were slightly less damaged than the three-day ones. The seven-day blocks showed no visible improvement on the five-day blocks.

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The Portland cement blocks were first tested at seven days and collapsed completely. After a fortnight, results corresponding roughly to *Ciment Fondu* at three days were produced.

Blocks tested at three weeks and one month gave practically identical results, similar to *Ciment Fondu* at five days, except that the whole upper surface became slightly concave.

The general inference drawn is that *Ciment Fondu* concrete is slightly superior in resistance to Portland cement concrete, and develops almost its final strength in about five days as opposed to about three weeks in the case of Portland cement concrete.

Absorption Test.—The object of this test was to compare the absorption of water of *Ciment Fondu* concrete with that of Portland cement concrete. Four blocks of concrete made of a 1 : 2 : 4 mixture were made with each cement and carefully cured. They were then allowed to dry out thoroughly and were weighed dry. They were immersed in water for 24 hours and then taken out and reweighed. The results were as follows :—

Absorption after 24 hours, expressed as percentage of dry weight.	
Ciment Fondu.	Portland Cement.
·88	1·75
1·01	1·97
1·56	1·92
·74	1·79
Av. ... 1·05	1·86

Compression Tests.—Owing to lack of necessary apparatus, no compression tests have been done at Chatham. The following figures, published about a year ago in the technical press, are of interest :—

COMPRESSION TEST (LBS. PER SQ. INCH).

Age.	Neat Cement.		Cement and Sand 1 : 3.	
	Portland Cement.	Ciment Fondu.	Portland Cement.	Ciment Fondu.
24 hrs.	1000	6800	260	5000
48 ,,	2000	9800	780	5500
72 ,,	3750	10600	1020	5700
7 days	6350	11600	2350	6150
28 ,,	8700	12600	4100	6800

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Summarizing the results of the tests, we may say that *Ciment Fondu* is a cement giving a very high strength after 48 hours and ultimately yielding a concrete superior to that made with Portland cement. Its rate of setting, on the other hand, is about six times as slow as that of Portland cement, so that *Ciment Fondu* concrete mixes may be handled for a correspondingly longer time before placing, without loss of strength, and finally, that *Ciment Fondu* is a sound cement entirely free from expansion.

We have already seen how *Ciment Fondu* is making its way in French Civil Engineering. Considerable interest is also being taken in it in England. A paper was recently read before the Institution of Engineering Inspection by Mr. H. J. Davey on the subject of *Ciment Fondu*. The Building Research Board have also tested the material and issued a report.

It remains to examine its military possibilities, in the light of our experiences during the late war. The value of concrete for military purposes was clearly demonstrated, on account of its adaptability, the ease of transport of the raw materials, and the saving of steel in place of which it could often be used. Its use on active service may be roughly considered under three heads :—

(*a*) *Fortifications.*—Gun positions, pill-boxes, dug-outs.
(*b*) *Structural.*—Machinery and other foundations, concrete structures at Bases and on L. of C., roads.
(*c*) *Sanitation.*—Impermeable floors in cookhouses, latrines, hospitals, stables, etc.

It may be safely predicted that *Ciment Fondu* will give much better results wherever Portland cement has been used, and will extend the utility of concrete in other directions in which it was formerly impracticable to use it.

Fortifications in the field may be of two classes, the rear lines of defence, deliberately prepared under almost peace-time conditions, and defences prepared under continued enemy interference. As regards the former, Portland cement concrete will meet the case, provided that the dispositions are decided on in plenty of time ; or, if the time is short, some provision of cover may be effected with the aid of precast concrete blocks, provided that a large stock of matured blocks exists. But the fact remains that, if an unexpected situation arises, it is impossible to provide good cover for men and machine-guns in less than three weeks. The use of *Ciment Fondu* in such cases would supply a very urgent need ; it should be quite possible, with its aid, to make dug-outs for men and M.G. emplacements which would give good protection in four days from the start of the excavation ; while the advantages of the new material to an army in retreat are hard to over-estimate.

The use of concrete in close trench warfare has several limitations :

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the time of curing, the weakness of the structure for the first few days, which renders it liable to be destroyed by a small chance shell, and the difficulty of mixing the concrete under good conditions and with adequate supervision. There is no room in the trenches to mix concrete properly; the water supply is usually bad, all kinds of mud and dirt find their way into the mixture, and enemy disturbances may lead to some of the concrete being placed long after the initial set has taken place. Here, again, *Ciment Fondu* bids fair to provide a solution to the difficulty. In addition to its rapid hardening qualities it has the very slow initial set of about two hours, this means that the mix may safely be handled and placed after a much longer period than is permissible in the case of Portland cement mixes. It would be useful and interesting to discover by experiment what the maximum safe period is, but, in the absence of the apparatus for crushing tests, the experiments cannot be done at the S.M.E. Probably the safe period is about 1½–2 hours. In consequence of this slow rate of setting it would be unnecessary to mix the concrete on the site of the work, a more suitable and accessible spot further back could be used and the mixed concrete sent up in bags and placed. This method would have the further advantage of reducing the amount of work going on at the site and so lessening the risk of detection by the enemy. A further development which suggests itself would be the formation of several central mixing places, possibly using machine mixers, in each divisional area, from which units could drawr eady-mixed concrete for any particular job. The advantages from the point of view of R.E. supervision would be enormous and the scheme would help to make other arms of the service more self-supporting in their defence work.

The application of *Ciment Fondu* to concrete for structural and sanitary purposes' work requires little explanation. Time is again the ruling factor; hasty foundations have often to be improvised from unsatisfactory substitutes for concrete, such as timber baulks and steel joists, when they could be much more efficiently done with *Ciment Fondu* concrete in only a slightly longer time.

Concrete floors are very necessary in field hospitals and standing camps, to prevent the pollution of the ground and the spread of infection. Portland cement concrete is unsatisfactory for this purpose, owing to the difficulty of preventing the troops from using the floors before they are properly set. Many concrete floors were ruined in this way during the war, representing a serious waste of material and skilled labour. At best there is a vexatious delay before the floor can be used. The only satisfactory solution to the floor problem is the use of *Ciment Fondu*, which will enable the floor to be used for light traffic the day after it has been laid.

Perhaps the greatest possibilities of the new material lie in its application to road-making. The advantages of reinforced concrete

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for forward roads have probably never been seriously considered, owing to the prohibitive length of time required for hardening the road itself and also any repairs in case of damage by shell-fire. Such roads present two very great advantages for active service work, the elimination of soling with the large expenditure of time, labour and material involved, and the large reduction in maintenance. *Ciment Fondu* will reduce the time of hardening to a fraction of that required for Portland cement and will give a harder-wearing surface. What the actual time required is can only be determined by large-scale experiments, but a period of five days is probably an outside estimate for the heaviest classes of traffic. The French have carried out successful experiments with a road for tanks, but details are not, so far, available. In view of the vital importance of road-work in war, it is most desirable that experiments be carried out in this country, both to explore the possibilities of such roads and to accustom R.E. personnel to the work.

At present the progress of *Ciment Fondu* in England is severely handicapped by the difficulty and expense of obtaining it. It is only manufactured in France, where the cost of production is about double that of Portland cement, and its price, delivered in London, is about £9 per ton. Though its composition is somewhat similar to that of Portland cement, it cannot be made from the same raw materials, for the clay used in the latter contains too great a proportion of silica; according to a report published by the Imperial Mineral Resources Bureau, deposits of bauxite in the British Empire exist in Ireland, India and British Guiana. The future of *Ciment Fondu*, therefore, depends upon the creation of such a demand as will justify research to cheapen and extend production. It remains, therefore, for us to demonstrate its military possibilities and assist in creating this demand, so that in the next war we may be able to satisfy the urgent need of every arm of the service for a rapid hardening concrete.

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STAFF WORK.

By D.B.

I WAS never a Staff Officer till the war. Then I became one by accident. My views are probably very unorthodox, but they may be useful to any would-be administrative Staff Officer.

A General Staff Officer has to depend on information, only a part of which he can verify: some of it may be false through the honest stupidity of those who get it for him, some may be intentionally false, and much must be intelligent guesswork about the secret intentions of other people. You, as an administrative Staff Officer, have access to every sort of knowledge you can want to arrive at a correct decision. What you cannot find out for yourself you can, and must, get from the General Staff. For example: How many sandbags will be required next month? The General Staff will give you, if you ask for it, enough information about probable operations to enable you to calculate. The information is secret, the very next day may falsify it, you must use it intelligently and revise it frequently. Just as you would use a reasonable factor of safety in building a bridge, you allow a reasonable margin in your provision of sandbags. If you are reckless, factors of safety and margins will be too small; if you are stupid, you will waste money, transport, and time, building extravagant bridges, or accumulating useless sandbags.

Though it is very easy to be a good administrative Staff Officer, it is easier still to be a bad one. A few hints may help.

In banking and in business generally, experience has shown that the overwhelming majority of men are honest. The very first thing any Staff Officer must learn is that the overwhelming majority of other officers are honest. If you think that X has made an unreasonable request just to annoy you, you are almost certainly wrong. X may not know what a lot of important things you have to do; he may be neither unreasonable nor lacking a sense of proportion; it is not his fault that his outlook is restricted by the duties he has to do. A civil explanation can do no harm; there may be more in X's request than you think; and even if X is stupid and unreasonable he cannot be annoyed at being treated as neither.

The next thing you must learn is to avoid making heavy weather of your work. To begin with, you are not conferring any favour by doing it, no matter how well you do it. You must never, never, never explain how difficult your work is. Nobody wants to know, nobody cares. What's more, they will think you a fool quite unfit for your job if you insist on talking of your difficulties. If one must descend to low motives, isn't it obvious that no one would think of

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giving any better job to a man who makes heavy weather of his present one? There are a lot of ways of making heavy weather, and they must all be avoided. Here are a few.

Consulting others about things you can decide yourself. For example, some simple thing is proposed that would add to the comfort of troops without in the least impairing their efficiency. You know that you should consult the General Staff about anything that might affect the efficiency of troops. If you are an advertising ass you seize the excuse and tell the General Staff that if they concur in "this excellent proposal" it will be carried out. The General Staff say "all right." If you repeat this sort of thing the General Staff (and everyone else) will think: "this fellow is trying to advertise, and he's wasting our time and delaying his work to do it." A similar reference to some other officer will make him think: "this fellow funks responsibility, he's trying to make me responsible." Result: useless correspondence while the proposal is delayed.

Much worse than needless consultation is the pernicious habit of answering questions that are not asked. For example, some appointment has to be made and the necessary correspondence comes near its end with this:—

"The appointment is approved, please submit the name of a suitable officer."

You, as a good Staff Officer, will answer thus:—

"Lieutenant X. Y. Zones."

You have given the name you were asked for; you were asked for nothing else; so you stop. A bad Staff Officer cannot stop: he proceeds to explain why Lieut. X. Y. Zones is suitable. The reasons so gratuitously given may not strike other people as convincing. So a new correspondence is started. Or they may appear to be an attempt to evade responsibility for the nomination. The result is the same: more correspondence. By the time it is done Lieut. X. Y. Zones has got another job, or has gone abroad, or died. All because a garrulous Staff Officer cannot answer a question about the pen of the uncle without dragging in some yarn about the cat of the grandmother. That sort of thing may be good for learning languages, but it is no use for business. Yet it is painfully common. About three-quarters of the official correspondence during the war was a history of the cat of the grandmother.

Another vicious habit is writing to the man next door. It may take a day getting to him. He may refer it to someone who never heard of it, takes no interest in it, and puts it away to be read later on when he is less busy. If some further bits of the history of the cat of the grandmother haven't got into it before you get the paper back, your luck is too good to last. Don't write to the man next door. Write the shortest and clearest possible statement and bring it to

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him yourself. Talk to him if you must, watch him well, and the moment you see he agrees, stop talking. Get his signature and vanish. He might change his mind if you waited, he might even think you wanted him to. Don't think he is too busy to see you, the busier he is the more you save his time by coming to see him. You save him from having to read irrelevant bits; you answer his questions at once; you give him no superfluous information; and in three or four minutes he has saved himself half an hour's work. You have saved yourself even more.

You gain something else by going to see people. You get to know them and they get to know you. Some—they are few—you may find stupid or obstructive. Avoid them if an enterprising junior in their office will do their job. If that is impossible, try blarney. Even a clever man can be made to think a proposal he never dreamt of was originally his own. Make a few objections that just, but only just, betray their foolishness. That will draw him unless he is more than clever. He'll think you a fool and argue for the proposal. Get his signature quick and clear out. There is a last resort that I can describe only by giving an example. A is the head of a branch, B his trusty henchman. They are strongly opposed to a scheme that X and Y are quite certain is a good one. A and B have more than once defeated X and Y when the scheme was proposed. It is time to try again. Y suggests a conference. Agreed. He tells A that B is chock-full of arguments against the scheme and will certainly trot them out at the conference. He tells B that A is sure to blow the scheme to bits if he can. At the conference A waited for B, B waited for A. Neither spoke, each thought the other had sold him. The scheme went through. Fortunately for Y the scheme was a success, and A and B got much credit for it. But it was a risky, low-down trick. Always talk things over and settle on a spokesman *before* a conference.

If you have much work to do you must have some organization in your office, but let the organization grow, don't force it. In a bygone war—a thing that could not have happened in the war against Germany—there was a beautifully organized ministry of inventions. Only C3 professors and senior wranglers could be in it. The first branch of the ministry dealt with inventions that could not work: impossible inventions. The second with inventions that were not inventions: someone else had invented them first. The third branch was to have the tranquillity that is absolutely necessary for dealing with really good inventions. Very few inventors got beyond the first branch, none got beyond the second. The organization was too good.

If, in spite of all these useful tips you find you are not a success as a Staff Officer, don't worry. You are well out of it: it's a dog's life, anyhow.

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NOTES ON PLATE-LAYING IN INDIA.

By CAPTAIN G. H. S. KELLIE, M.C., R.E.
O.C. 25th (Railway), Co. Royal Bombay Sappers and Miners.

MY Company being at present employed by the Bengal Nagpur Railway on the construction of a 5 ft. 6 in. gauge branch line in Chota Nagpur, it is thought that a few notes on the methods of plate-laying may be of interest to some officers.

The line is some 65 miles long and takes off the main Calcutta-Nagpur line about 170 miles west of Calcutta, from a small station called Amda. The line is being constructed to open up large iron and other deposits in the Singhbum District and Keonjhar Native State. It is being laid with 90-lb. F.F. rails on wooden sleepers, the normal length of rail being 36 ft. Stations, sidings, etc., are, however, of 75-lb. F.F. rails on plain steel trough sleepers.

Linking is carried out by means of special rail-carrying trollies designed by A. Anderson, Esq., one of the Assistant Engineers of the construction, to whom I am indebted for permission to describe his methods. The use of these trollies obviates practically all heavy manual labour as far as bringing up and laying rails is concerned. Besides the usual outfit for linking the following extras are used :—

(1) One or more " feeder " rail trollies, each carrying 4 rails.
(2) One light " linking " trolley, carrying 2 rails.
(3) A pair of light angle irons or " I " beams on which the linking trolley runs in extension of railhead.

To describe these in detail, taking No. 2 first :—

Linking Trolley.—This consists of 6 parts—2 axles and 4 wooden levers. The axles are of the ordinary light trolley type about 1½-in. diameter, having 24-in. wheels. On the axle, 3 in. inside the boss of the wheel, is a fixed ring which acts as an inner bearing guide. The levers are 3 in. × 2½ in., 12 ft. long. One foot from one end of each lever is bolted a simple " U " bearing of strap steel. This runs on the axle and forms not only the trolley-bearing, but also the fulcrum point of the lever. At each end of all the levers is affixed a self-gripping clip of the usual " tongs " pattern. To assemble the trolley, no fastenings are used, so that it is instantly demountable, any one of the 6 parts is capable of being carried by one man.

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Feeder Trolley (see *Plates* 1 and 2).—This is an amplification of the linking trolley, and consists of the following parts :—

2 heavy material trolley axles and wheels.
4 master levers.
2 yokes.
4 ordinary levers.

One foot from one end of each master lever is bolted an ordinary cast-iron material trolley-bearing, which acts as the trolley-bearing and the fulcrum point of the lever. On the upper side of each master lever, immediately over the bearing, is a pair of chocks, spaced to receive the yoke, which lies over and parallel to the axle.

The yoke in its turn is chocked on its underside to keep it in position on the pair of master levers and again on its upper side for the ordinary levers. It will be seen that the fulcrum point of the master levers is the axle and that of the ordinary levers the yoke. All levers are provided at their ends with rail clips. The trolley, like the linking trolley, takes to pieces down to one man loads, with the exception of the axles which are unnecessarily heavy. However, they are the only suitable articles of store available.

Railhead Extensions.—

(1) For straight line or level joint curve linking, a pair of 4 in. × 4 in. angle irons, 27 ft. long, are used. At the rear end the "flange" of the angle iron is cut away for 9 in. and the top of the "web" is cut down to 1½ in. for the same distance. A single fish-bolt hole is drilled in this tongue so as to register with the outer fish hole in the rail. The flange at the front end of the angle iron is cut and turned up so as to act as a trolley stop.

The angle irons are laid on the sleepers with their "webs" vertical and the flanges turned away from each other, the trolley running on the edge of the "web." Gauge is kept at the rear end by placing the tongue of the angle iron against the inner side of the rail web and passing a slotted pin through the outer fish hole of the rail, the pin being held in place by a loose key. At the forward end a loose bar clips over the flanges from underneath.

Each angle iron is carried by 4 men. Bamboo and chain slings are permanently attached to ring bolts bolted to the flange.

(2) It is the practice on this construction to lay all curves of 3 degrees and over with staggered joints, *i.e.*, with one rail leading the other by ½ a rail length. In this case one of the extensions has to be 45 ft. long. At present 4 in. × 3 in. "I" beams are used, junction with the rail being effected by a double plate, bolted to the web of the beam, which is

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slipped over the rail web. A pin is not found necessary. An 18-ft. length of the 45-ft. extension is detachable so that the pair of "I" beams can be used for straight or level joint curve linking. Four men carry the 27-ft. length and 6 men the 45-ft., light rail slings being used.

Linking Procedure.

(*a*) There are two methods of placing rails in the track so that they can be picked up by the rail-trolleys.

(1) The rails are thrown off the rail truck in the usual fashion and are then placed in the track either by men with crowbars or by direct lifting with slings. This method is very slow if the rails become at all locked in unloading.

(2) An 80-ft. wire rope is attached to a sleeper (in the track) by means of a "U" hook. The other end splits out into 4–6ft. chains, each provided with a hook. The hooks are placed in the fish holes of the rails and by setting back the train the 4 rails fall in the centre of the track. This method is very quick, saves one operation and is very good when the formation is narrow. It does not work well on very sharp curves, as the rails are apt to slew sideways and fall outside the track. It is dangerous to put men up on the truck to guide the rails as they are falling.

(*b*) The train is then set back clear of the rails lying in the track. The feeder trolley picks up 4 rails and drops them about 6 joints in rear of railhead.

(*c*) The linking-trolley picks up the outer pair of rails dropped by the feeder-trolley. The rear pair of levers picks the rail up by the fish-bolt holes and the front levers clip on as far back as they can without fouling the rear levers. In the travelling position there is, therefore, about 10 ft. of rail cantilevered out in front. The trolley is then run up to railhead and along the extensions until the rear ends of the rails are level with their final positions. The rails are dropped and the two halves of the trolley taken away at the double. The new rails now lie about 8 in. inside their final position.

(*d*) The angle iron parties unkey the angle iron and carry it ahead.

(*e*) Two men bar each rail outwards into the adzed seats on the sleepers.

(*f*) The joint is fished with 2 bolts and spikes are driven at the 3rd, 8th and 13th sleepers (assuming 15 sleepers to the rail). The extension is then fished to the newly laid rail.

(*g*) The linking-trolley comes up with a fresh pair of rails and the process is repeated.

Note.—(1) Only those operations peculiar to the method of linking have been described.

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(2) On curves with staggered joints the 27-ft. extension is fished to the leading rail. The trolley is thus enabled to drop each rail as it comes into position. The trolley can pick up and move one rail at a time without difficulty. Care should, however, be taken not to push the axles out of square with the track.

GENERAL REMARKS ON THE METHOD OF LINKING.

(1) There is a very considerable saving in manual labour.

(2) The possibility of accidents through the rail falling are reduced to a minimum. In the travelling position the foot of the rail is about 2 in. above the heads of the rails in the track, *i.e.*, 7½ in. above sleeper level. This is sufficient to clear points and crossings, level crossings and normal obstructions in the track.

(3) The supply of rails is not hindered by a narrow formation in the bank or cutting. In the case of carrying rails by hand this is an important consideration. It is no easy matter carrying a heavy rail over sleepers.

(4) Very small parties can carry out linking. Recently a platoon of my company, 30 strong, spread all sleepers and linked 19 pairs of 90-lb. 36-ft. rails in 3 hours. All sleepers were spiked. To take an extreme case, it is actually possible for a party of 4 men to link ! In this connection it may be mentioned that when the trolleys are closed up so that the levers of one axle rest on the other axle they form very handy trollies for carrying sleepers.

It is not possible to give any satisfactory figures regarding the speed of linking. We have always laboured under difficulties owing to lack of labour, material, etc. Our chief trouble is the formation, which the contractors only think about finishing off as the rails arrive. Given a decent formation, 2 minutes per joint is a good average when everything is running smoothly.

(5) This method is essentially designed for F.F. rails on wooden sleepers, but there is no reason why it should not be used on plain trough sleepers. It is most economical when heavy rail sections are used.

(6) If the N.C.O. i/c angle party does his job the line requires practically no preliminary straightening to pass the train.

(7) The local " jungly " learns very quickly how to use the levers of the trolley. A weak cooly can operate the rear levers of the linking-trolley by himself, but requires assistance on the front levers.

(8) On down grades either trolley can be braked by releasing the front clip of a rear lever, thus allowing one rail to drag over the sleepers.

The following is a distribution and strength of parties Table. In many cases we have to economise owing to lack of coolie labour.

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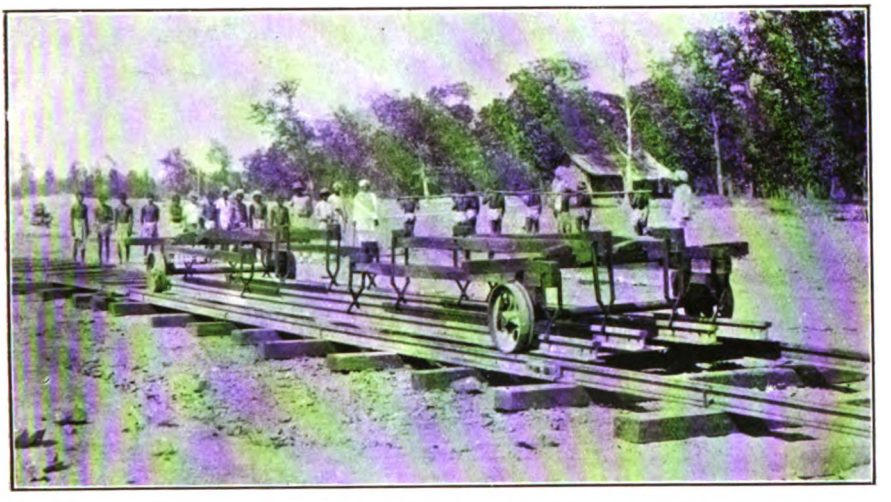
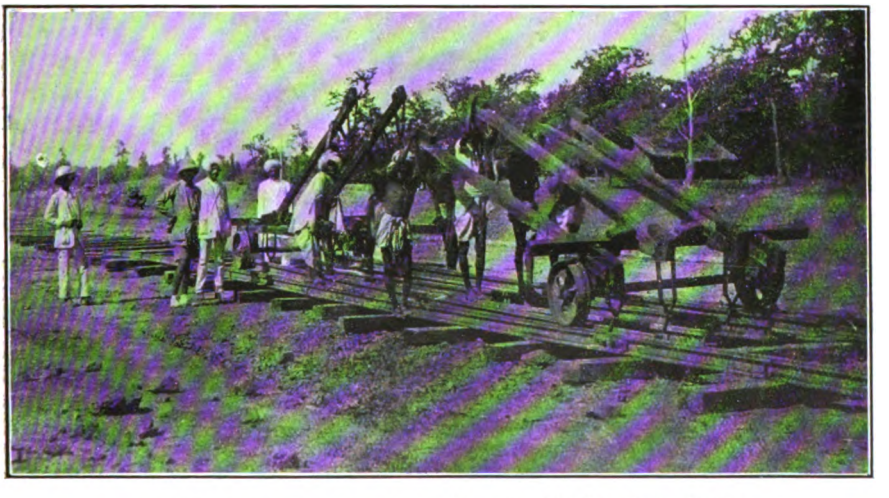
NOTES ON PLATE-LAYING IN INDIA.



(1). The "Feeder" Trolley in the Travelling Position.



(2). The "Feeder" Trolley about to Lift its Four Rails.

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Detail of Parties.

	N.C.O.'s	*Sappers*	*Coolies*
1. Sleeper Carriers and Spacers	2	—	as available
2. Material Spreaders	—	2	12
3. Angle Iron Party	1	8 (*a*)	—
4. First Fishing Party. (Also help party, No. 3)	2	6	—
5. Barring rails into adzed seats and holding up rails for fishing party ...	—	4	—
6. First Spiking Party (sleepers 1, 8 and 13)	1	12	—
7. Rail Square	1	—	—
8. Linking-Trolley Party	1	8	—
9. Second Spiking Party (sleepers 1, 6, 11, 15)	1	16	—
10. Preliminary Straightening Party ...	1	6	—
11. Second Fishing Party ... ... N.B.—The 3rd and 4th bolts are not put in till the line is being packed. These men only tighten the work of 4.	—	2	—
12. Placing rails for the rail carriers ...	—	4	—
13. Marking rails for spacing	1	—	—
14. Feeder-Trolley Party	1	—	16
15. Placing rails in the track, using crowbars	1(*b*)	8	—
16. Final spiking, straightening, fishing and packing	Labour is usually insufficient to carry these on at the same time. Spare time or special days are allotted for this work.		
17. Spare men on 15, usually about ...	2	16	—
Totals	15	92	28

Notes.—(*a*) Staggered joints, 10.

(*b*) Using rail slings, 1 N.C.O. and 10 men.
Using wire rope, 2 N.C.O.'s and 8 men.

(General) Parties for unloading material have to be found from linking parties, on account of lack of labour.

Jamda.
25*th February*, 1923.

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ROADS CONGRESS, SEVILLE.

By MAJOR H. E. COAD, A.M.INST.C.E., S.R.E.S.

THE Fourth Meeting of the Permanent International Association of Road Congresses held in Seville in May, 1923, was useful in the fact that civil engineers from all parts of the world were brought into contact for the exchange of views, but the almost entire absence of public discussion was a grave drawback to the success of the Congress. This was unavoidable. The time at the disposal of the Congress was limited to one week. The work of interpreting discussions into two or more languages would have made free debate an endless and impossible task.

Six subjects were chosen for consideration, *viz.* :—

1. Surfacing of roads with concrete.
2. Use of bitumen and asphalt for surfacing.
3. Laying tramway rails.*
4. The development of motor traffic.
5. General traffic regulations.
6. The problem of traffic on congested roads and streets of towns.

Fifty-nine papers on these subjects, condensed from contributions from 158 leading engineers of all countries, were received. These were summarized and reported upon by Committees chosen from the representatives of Spain, France and the English-speaking nations. Both papers and reports were printed in the three languages and circulated to all delegates. The few hours at the disposal of the Congress were utilized in reading the conclusions arrived at by the committees. These conclusions were necessarily of an elementary description, upon which there could be little disagreement, for, had much of a debatable character been expressed, no agreement could have been arrived at in the allotted time.

The following gleanings from the papers may be found useful :—

1. CONCRETE ROADS.

Materials.—Any hard stone or gravel may be used for the aggregates, provided the material is tough enough to resist stresses of traffic without crushing. This eliminates any soft limestone. All material must be perfectly clean. Grading to eliminate voids as far as possible is important. The sand should contain only a small percentage of fine grains, as these produce a weak film on

* Further mention of this subject is omitted as being of insufficient interest.

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the surface of the concrete. Various types of reinforcement have been used with no apparent important difference in result, whether placed near the surface or towards the bottom of the slab.

Plant.—A mechanical plant is most desirable, since it ensures regularity of mixing and rapidity in laying. The mechanical tamper and finishing machine allows of comparatively dry concrete being used. Mechanical devices riding on the side forms and designed to cut the subgrade to true elevation are increasing in favour. Side forms of specially-rolled steel shape are in almost universal use in the United States.

Proportions.—For one-coat work the proportions 4/2/1 should not be exceeded. For two-coat work, the base may be 6/1/1 and the surface of finer aggregate of 3/1/1. One-coat work is preferable, since it ensures greater homogeneity for expansion and contraction and admits of greater speed in laying. With regard to this somewhat rich mixture of cement, the delegates from the United States expressed an opinion that a weaker mixture might be equally efficacious. They were in the habit of using 3/2/1 and 4/2/1, but thought the reason of so doing might be traced to the influence of the cement manufacturers in that country.

Reinforcing versus Ordinary Concrete.—Ten-inch thickness of ordinary concrete appears to be approximately equal in strength to 6 in. of reinforced concrete. On firm road-beds there is no apparent advantage in reinforcing, other than the saving in the cost of materials. Beds are, however, rarely firm all over and therefore reinforcement is desirable.

Formation of Carriage-way.—It is desirable that the foundation bed should have the same camber (about 1/48) as the surface, and it should be thoroughly consolidated. Where the subsoil is wet, it must be drained, and, if the subsoil is clay, a separating medium such as ashes, clinker, sand or ballast, rolled to a consolidated thickness of 2 in. is desirable.

Thickness.—A thickness of 6 in. is an absolute minimum and 8 in. reinforced or 10 in. unreinforced are desirable minima for heavy traffic.

Construction.—Wherever possible, full-width construction of new roads should be adopted, as failures have occurred in cases where the whole of the traffic has been diverted to one-half of a new road. The concrete should be kept damp for two weeks and free from traffic for four weeks.

Cracks are considered to be inevitable, whether expansion joints are used or not. The difficulty found in making an expansion joint, without, at the same time, causing an inequality of surface, counteracts any advantage which might be gained by lessening the number of transverse cracks.

Advantage of a Concrete Road.—The main advantage lies in the

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stability. It is free from deformation, corrugations, tracking and waving. A concrete road offers less resistance to traction than one which is pliable. A new concrete road can be laid at a cost not greatly exceeding that of other methods. It can be resurfaced with either new concrete or with asphalt.

Disadvantages.—The length of time required to allow concrete to be laid and cured, and similarly the time required for hardening patches necessitated by trenching, are undoubted disadvantages.

2. Use of Bitumen and Asphalt for Surfacing.

Compressed Rock Asphalt Process.—This process consists in heating and depositing, raking and rolling a 2-in. surfacing of the compressed powder (Val de Travers, Seyssel, Limmer or Ragusa) on a prepared bed of Portland Cement Concrete, 6 in. to 12 in. in depth, according to the degree of traffic. The qualities of the powder for road-making seem to depend more upon the fine grain of the limestone than upon the character of the impregnating bitumen. The percentage of bitumen varies from 6 per cent. to 16 per cent., the best percentage for work in Great Britain being between 10 per cent. and 11 per cent. This type of asphalt is suitable for roads carrying very heavy traffic, but on account of its high initial cost would appear to have no great future.

Mastic Asphalt Process.—In this process similar ingredients to those used in the compressed rock asphalt process are employed, with the addition of a sufficient percentage of bitumen to bring the mixture to such a consistency that it can be floated by hand with wooden trowels. Usually the mastic is first made into blocks, which are melted upon the site of the work; the final addition of bitumen and chippings is then made before depositing the mixture on the prepared foundation. The latter may be either prepared water-bound macadam or a concrete foundation. When prepared from natural rock asphalt, the rock is pulverized to such a degree that not less than 60 per cent. passes the 200 mesh. This powder is digested in bitumen at a temperature of 350° F., bitumen being added until it forms not less than 15 per cent. of the whole. The mixture is then moulded into 60-lb. blocks. These are remelted on the site of the work and clean $\frac{1}{4}$-in. to $\frac{3}{8}$-in. granite or limestone chippings are added up to 40 per cent. by weight. This process is now being extensively employed on ordinary water-bound macadam surfaces, a consolidated depth of 2 in. to 3 in. of asphalt being laid. It is suitable for a lighter traffic and is a cheaper process than the preceding one.

The Two-Coat Asphalt Macadam Process consists of a binder-course or base-coat of asphaltic concrete, with a wearing-surface composed of mineral aggregate bound together with asphalt, cement or

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bitumen. The existing road-bed is reformed and consolidated with steam-rolling and 2 in. to 3 in. of asphaltic concrete or "binder," and 1 in. to 1½ in. of fine asphalt wearing-surface laid on it. The asphaltic concrete consists of, approximately,

65 per cent. of concrete, granite, whinstone, slag clinker or gravel, broken to 1½-in. to ¼-in. gauge.
28 per cent. of fine sand as a filler.
7 per cent. of bitumen.

The wearing-surface consists of a sand aggregate combined with a predetermined proportion of filler and bitumen. In modern practice the sand selected for the aggregate carries about 12 per cent. by weight of soluble bitumen and contains little or no 200-mesh grains and not more than 12 per cent. of 50-mesh grains. Between the 100 and 50-mesh, the sand should be as evenly graded as possible. The filler consists of Portland cement, ground chalk, limestone or slate dust. A minimum of 10 per cent. by weight is used, its function being to add density to the bituminous coating of the sand-grains and to close the finer voids. A well-graded wearing-surface should have approximately the following analysis :—

Bitumen soluble in CS_2				...	...	12	per cent
Sand passing	200	mesh		...	...	16	,,
,, ,,	100	,,		...	...	14	,,
,, ,,	80	,,		...	...	10	,,
,, ,,	50	,,		...	...	36	,,
,, ,,	40	,,		...	...	5	,,
,, ,,	30	,,		...	...	3	,,
,, ,,	20	,,		...	...	3	,,
,, ,,	10	,,		...	...	1	,,

This two-coat asphaltic macadam is used in secondary city streets and also in surfacing country roads, in fact, wherever the traffic is not excessively heavy.

Single-Coat Asphalt Macadam Process.—This process is similar to the mastic asphalt process, except that sand is used for the aggregate instead of the crushed impregnated limestone. The mixture also is applied to the road by means of raking and steam-rolling (thickness 2 in. after consolidation) instead of being hand-floated.

The ordinary surface mixture with sand aggregate as described in the two-coat work is taken as a base, and to this is added from 10 per cent. to 40 per cent. of granite or limestone chippings broken to less than 1-in. gauge.

The formula for this process may be taken as :—

Bitumen	... 12 per cent.	(*a*)	Stone	... 95 per cent.	(*b*)
Sand	... 72 per cent.		Bitumen	... 5 per cent.	
Filler	... 16 per cent.		(for coating this stone)		

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The mixture consists of 60 per cent. of (*a*) in proportion to 40 per cent. of (*b*).

This process is useful where the traffic is not heavy and where a firmly consolidated road-surface is available without radical reconstruction. It is thus a cheaper process than the preceding one and has been extensively used for resurfacing stable water-bound roads and worn tar-macadam roads.

Sheet Asphalt Process.—This process is used extensively in the United States for heavy street traffic, the asphalt being laid on a Portland cement foundation 6 in. to 8 in. thick. It generally consists of two courses, the binder course and the wearing-surface, both 1½ in. thick. The process is similar to the two-coat asphalt macadam previously described. The stone in the binder course is of 1-in. gauge and a typical formula is as follows :—

	Binder	*Surface*
Stone ...	840 lbs.	—
Sand ...	210 lbs.	814 lbs.
Filler ...	—	165 lbs.
Bitumen ...	50 lbs.	121 lbs.

The hot mixture is deposited in place with heated shovels, thoroughly " fluffed up " with rakes and raked to a true grade. It is then rolled with a 10-ton roller at a speed not exceeding 2½ miles per hour, first parallel to the curb and finished with cross or diagonal rolling to eliminate ridges. The binder mixture should reach the work at a temperature of about 250° F., and the surface mixture at about 300° F.

Asphalt Block Pavements.—The blocks are composed of hard, crushed stone of less than ⅜ in. gauge, filler and bitumen, to the following formula, *viz.* :—

Crushed stone ...	70·75 per cent.
Filler	15–20 per cent.
Bitumen	6–8·5 per cent.

The ingredients are heated and thoroughly mechanically mixed. The resulting material is then pressed under high pressure into blocks of size 12 in. × 5 in. × 2 in.

The blocks are usually laid on a mortar bed ½ in. thick, spread over the concrete foundation of the road. They are laid with close joints. Sand is then swept into the joints and as the blocks are malleable, they soon weld together into a smooth, durable pavement.

Grouting or Penetration Process.—Hard rock is broken to 2-in gauge and is uniformly spread over the road and lightly rolled to a consolidated thickness of 3 in. Pure bitumen grout or a mixture of sand and bitumen is poured over the surface to fill the interstices, clean chippings are spread, and the whole consolidated by rolling.

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Finally the surface is swept and a sealing coat of bitumen applied. This type of construction is cheap and easily carried out, but it is essential that the surface should be dry. The process cannot, therefore, be successfully performed in wet weather.

Bitumen Surface Sealing Process.—The essential factors to success are :—

1. Complete stability of the surface to be treated and the removal of all dust.
2. Fine weather.
3. An adhesive elastic and stable quality of bitumen.
4. Dry *cubical* chippings, free from dust.

Sealing water-bound surfaces with bitumen is unsatisfactory for the following reasons :—

1. Periodical alteration in contour. Owing to the variation in subsoil water-level in the summer and winter the height of a water-bound road increases during the winter months.
2. Under heavy traffic, moisture is forced through the thin sealing coat; in fact, this thin coat, laid on a partially unstable foundation of macadam, is insufficient to carry heavy traffic.

On the other hand, good results have been shown in the application of bitumen sealing coats to new and old tar-macadam roads, the natural affinity of the tar for the bitumen ensuring a close joint.

4. The Development of Motor Traffic.

Mass production of motor vehicles under Government subsidies in order to make them as cheap and perfect as possible is desirable. Of the whole number of motor vehicles in use in Great Britain, it is estimated that 80,000, or one-eleventh, are Ford cars. This is attributable to the cheap price at which a standardized vehicle, produced in mass quantities, can be sold. The output of the Ford Works in Detroit, U.S.A., is given as 750,000 cars per annum.

In every country investigations are desirable to find the best and cheapest carburant of the country in order to be independent of foreign produce. Similarly with regard to tyres.

Passengers and goods motor-transport companies should be encouraged by Government subsidies.

The situation in Great Britain at present appears to be complicated and unsatisfactory. There are more motor vehicles than there is volume of traffic to keep them employed. Tentative proposals for clearing houses at industrial centres, where loads could be bulked and allotted and back loads could be secured, have mostly broken down. The only remedy would appear to be a slow process of

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amalgamation of existing companies and consolidation, the start of which is now in evidence.

As regards the second essential factor in the development of motor traffic, *i.e.*, the road, it is obvious that the most perfect road is that which is the shortest, the cheapest to construct and maintain, possesses the least pronounced gradients, and curves with the greatest radius, offers the fewest obstacles to rapid and free running, has the greatest width, so as to enable all classes of users to utilize it independently, and has the most resistant and durable surface with the lowest cost of construction and maintenance, without dust, moisture, cracks, etc.

Width.—The narrowest road should be not less than 20 ft. wide, *i.e.*, to take two lines of traffic. Every part of a main road system should be at least 40 ft. wide, *i.e.*, for four lines of traffic. Since permissible speeds of cars are likely to increase, widths of 60 or 100 ft. in main arterial roads, to enable overtaking vehicles to move unchecked, should be looked to. Such widths would allow special tracks for horse-drawn vehicles and tramways, as well as for pedestrians, these tracks being separated from the roadway proper by means of kerbs.

Gradients.—It is obvious that gradients restrict both speed and load. The maximum gradient recommended is 6 in 100, and the radii of the curves should not be less than 30 metres in mountainous countries and 100 metres on flat or nearly flat ground. Super-elevation on the outer part of the curve is recommended.

Freedom from Obstruction.—Level crossings over railways should be eliminated and, where this is impossible, visibility over 150 metres on each side of the track should be looked to. Humps over bridges obscuring the forward vision, weak underbridges incapable of supporting ordinary loads, overbridges of insufficient height over the roadway, should all be done away with. At all intersections of roadways there should be a setting back and easing of corners. A clear, continuous forward vision of at least 100 metres should be striven for.

Camber.—The smallest possible camber to ensure road drainage, not exceeding 1 in 30, is desired. Vehicles seek to hold to the crown of a heavily-cambered road, impeding each other and wearing out the centre portion.

Road Surface.—Whether the surface should be resilient or rigid has not yet been agreed upon. A compromise of a rigid substructure, deep and strong enough for heavy fast-moving traffic, with a protective surface-coat of resilient material would appear feasible.

Sign-posts.—Roads should be indexed and numbered. At cross-roads there should be concise information to indicate the direction and places served by each branch road. Wherever possible, such sign posts should be lighted at night. All indications and general

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signals on the road should be similar in every country and the direction of movement, either right or left-handed, should be uniform. The former is preferred.

Footpaths.—Adequate provision of kerbed footwalks to ensure the safety and comfort of the pedestrians should be allowed for.

Telephones.—Telephones for public use should be installed wherever possible alongside the road. The creation of good inns for travellers and depôts to serve as receiving or distributing offices for goods should be encouraged.

5. General Traffic Regulations.

Dimensions of Vehicles.—The limiting dimensions of vehicles cannot at present be defined, but it is desirable that the maximum width should not exceed 2·5 metres.

In Great Britain the governing width for motor wagons is 7·5 ft., with a usual length of about 30 ft. The maximum width for public passenger service vehicles used in London is 7·167 ft. Private motor-cars are also limited to this width. The average ratio of useful platform area to the total area of British vehicles is ·75 to 1·00 for goods vehicles driven by steam and ·85 to 1·00 for petrol-driven vehicles.

Weights and Speeds.—The maximum unladen weight for heavy motor-cars in Great Britain is at present 7·25 tons and the speed limit 20 miles per hour. A Government Committee has recommended the removal of the speed limit for motor-cars weighing unladen 2·5 tons or less, and not more than 3·75 tons laden, but this change is not yet in force.

As regards weight and speed, internal-combustion-engined vehicles are lightest and quickest, with steam-engined vehicles next and electric vehicles heaviest and slowest.

Width of Tyres.—Single-rubber tyres are frequently made with a rim width of 7 in., but the tendency is to multiply the number of axles and wheels as a solution of weight distribution rather than to increase the width of the tyre. Six-wheeled construction with an overall length of 33 ft. is on the increase in Great Britain.

Lighting.—An International Conference is recommended by the Congress to make uniform in all countries regulations on Lighting, Licences and Identification Plates. In Great Britain, a Government Committee has made certain recommendations which have been accepted in principle. Generally speaking, all motor vehicles are required to carry two white lights in front and a red light behind on the off-side. No part of the vehicle must project laterally more than 12 in. from the centre of each white light, and no part of the vehicle or its load must project longitudinally more than 6 ft. beyond the red lamp. In addition, headlights may be used and, to reduce

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" dazzle," regulations regarding the range and the dispersal of light of the lamps have been made.

Brakes.—Motor vehicles should be fitted with two brakes, sufficiently powerful to stop the vehicle on the steepest gradients. In Great Britain, front-wheel brakes are seldom fitted, but there are indications of developments of this class of brake which will bring them into use.

Average retardations of cars, with brakes in average condition and with drivers possessed of average technical ability and alertness, are found to be, for level ground, approximately :—

Speed in miles per hour.	*Distance required for stopping in feet.*
10	10
20	40
30	90
40	160
50	250

Pressure, hydraulic and vacuum braking have so far failed for road motor vehicles, and it cannot be said that the braking systems commonly in use have reached finality.

Drivers' Licences.—The British Departmental Committee on the Taxation and Regulation of Road Vehicles in March, 1922, found that the institution of tests of mechanical knowledge or of physical fitness, before the issue of motor-drivers' licences, was not justified. The Committee considered that a declaration on the part of an applicant for a licence, of freedom from disease or physical disability which would be likely to make his driving of a car a danger to the public, should be obtained. Apparently the chief control over a careless licence holder, apart from fine or imprisonment, lies in the power of suspension or cancellation of his licence.

Pedestrians.—In Great Britain, the pedestrian has a definite status on the carriage-way, and an exclusive status on the foot-way. " It is equally the duty of foot-passengers crossing a highway to take due caution to avoid vehicles, as it is for the drivers of vehicles to take caution to avoid foot-passengers." However, if a foot-passenger on the carriage-way is injured by pure accident, he has, apparently, no remedy, and, moreover, in an action, the onus is upon the pedestrian to prove negligence on the part of the driver of the vehicle.

Loose Animals.—The fencing of grazing-land cannot in all cases be enforced, nor can the movement by road of herds of animals be prohibited.

In the absence of proof of wilfulness in their destruction, or of gross carelessness on the part of the driver of the car, dogs, cats, or poultry can, apparently, be injured without expectation of redress on the part of the owner.

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6. The Problem of Traffic on Congested Roads and Streets of Towns.

The general opinion in the reports is that both drivers and pedestrians disregard regulations for the facilitation of traffic. The existing regulations are for the most part adequate, and it is considered that the authorities should be more stringent in exacting penalties for their infringements.

Prohibition of car-ranks next to foot-walks in busy streets, of central lamp-posts, overhead wire standards or of any other obstruction to traffic is recommended.

At street junctions, rotary circulation is recommended, with pedestrian crossing zones on specially coloured pavement strips. The rotary method, in which each stream of traffic pours into a circular track and each vehicle steers off at a tangent when the required opening is reached, is not very suitable for a great volume of traffic. In the absence of fly-over bridges or tunnels at road crossings, however, it appears to be the best solution. In very narrow but important streets, it is for consideration whether the foot-path cannot be placed in an arcade constructed within the building line. This has been adopted in Philadelphia, U.S.A., in a position where it was absolutely necessary to increase the width of the roadway, irrespective of cost.

Where a street is wide enough, it is desirable to divide each side traffic into two parts—slow traffic near the pavement and faster traffic towards the centre. The method of marking the centre-line (*ligne d'axe*) of the street with a white-painted line is very suitable for separating the traffic.

This central line gives greater confidence to the drivers, who know that there is little danger of collision with vehicles travelling in the opposite direction as long as they do not cross the line. Whilst useful on straight tracks, it is of greater value at curves.

Parallel streets should be used, where available, for slow-moving traffic. The fact that the obstruction of streets is in direct relation to the differences of speeds of vehicles is important; with speeds varying from 3 miles per hour to 35 miles per hour, it has been ascertained that a certain stretch of road reaches its maximum capacity with a traffic of 750 vehicles per hour. With a constant speed of 15 miles per hour, the same area will accommodate 5,000 vehicles.

The education of the public by methods similar to those employed by the British and American " Safety First " and " Children's Essay Competition " organizations, is most useful and these methods should be practised universally.

Systems of mechanical signalling for the regulation of traffic do not appear to be yet entirely satisfactory.

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SOME IDEAS ON THE FUTURE OF PERMANENT FORTIFICATION RESULTING FROM EXPERIENCES OF THE GREAT WAR.

By CAPT. AND BT. MAJOR R. P. PAKENHAM-WALSH, M.C., *p.s.c.*, R.E.

THE lessons of the Great War as regards permanent fortification have, naturally, not received the same attention from British military writers as they have from those of continental nations, who possess long land frontiers. It is important, however, that the matter should receive due attention, not only on account of the land frontiers which do exist in the Empire, but also in view of the fact that we may be easily once more embroiled in a continental war, in which the antagonists may have vulnerable land frontiers.

Military mechanical science has advanced a long way since 1914, and improvements in air forces, tanks, and gas are daily changing the material side of war. For this reason it may be argued that the present is not an opportune moment for the discussion of the developments of an art, the products of which must stand for so long a time.

But the same arguments might have been produced all down the ages. Each war has found the design of existing fortifications out-of-date. Nevertheless, these fortifications have, to a greater or less degree, achieved the object for which they were constructed. 1914 was no exception to this rule, and found the fortifications of Europe, almost without exception, out-of-date in view of the enormous advance in weapon power.

The object of this article will be, in the first place, to consider to what extent the fortifications existing at the outbreak of the Great War fulfilled the purpose of their designers and, where they failed, to endeavour to trace the cause of failure. It will then be possible to look forward and get some ideas as to the future of permanent fortification. Lest there be any misunderstanding, let us at once get away from the idea that the fortresses of the future will of necessity bear much resemblance in design to the nineteenth-century European fortress. Principles may remain the same, but the design may vary as much as the Vauban fortifications of Ypres do from the *Feste* system adopted in Metz. For this purpose we must not be tied by the definition of a fortress as given in *Field Service Regulations*, Vol. II, 1920, which reads : " The term fortress implies

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a girdle of mutually supporting works designed for the protection of some town or area of importance." This definition may be accurate enough for the moment, but for the student endeavouring to meet future conditions no such narrow limits can be accepted.

Before considering the extent to which the fortresses existing at the outbreak of the War affected the course of operations, it is necessary to understand the purposes for which they were designed. Perhaps the simplest definition is that given in Major-General Bird's *Direction of War*: "Fortification is normally employed to economize force, to free troops for active operations, and to hamper the movements of the enemy." This definition is applicable to all forms of fortification, but perhaps does not stress sufficiently the offensive as well as the defensive use of fortification. On this point Napoleon says: "Fortresses are equally useful in offensive as in defensive warfare. It is true they will not, in themselves, arrest an army, but they are excellent means of retarding, embarrassing, weakening and annoying a victorious enemy." Jomini in an endeavour to be more precise, divides the objects of fortification into two main rôles:—

(i) To cover frontiers (*i.e.*, the defensive rôle).
(ii) To assist the operations of a campaign (*i.e.*, the offensive rôle)

To go into more detail, the following headings summarize the main objects of pre-war fortification:—

(*a*) To cover areas of importance from a political, economic or military point of view.
(*b*) To hinder an enemy's advance by narrowing or breaking up his avenues of advance, by delaying him and compelling him to make large detours, by threatening his communications, or by forcing him to make detachments.
(*c*) To assist the offensive action of the field army by affording jumping-off places and pivots of manœuvre for an attack, by economizing men on inactive parts of the front and on the L. of C., or providing stages or links in an advance.
(*d*) To assist defensive action by immobilizing numerically superior portions of the enemy's forces, by covering the retreat of the field army if driven back, and affording it rallying points or a refuge if seriously defeated.

However, with all these objects in view, as Captain (now Major-General) Thuillier pointed out in *Principles of Land Defence* (1902), the prime object of all permanent fortification is to gain time, and on the relative length of time a fortress can continue to achieve its object depends its value.

To gain time for one or more of the objects given above each of the great continental fortresses had been designed. Some were

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successful in gaining their object, others failed, while still another class fulfilled an object for which they were not primarily designed.

The first class to be considered are those great self-sufficient ring fortresses, designed, not so much for playing a part in the plan of operations, as for providing a refuge for the Government or the Army, when the latter, for the time being, could not maintain itself in the open field.

In this class fall Antwerp, Bucharest, and Paris. All three were called upon to carry out the task assigned to them, and not one of them fulfilled it.

Antwerp, on which much money had been expended in recent years, and which might, therefore, be considered by the Belgian nation as up-to-date, was given up by the Field Army and the Government as soon as it became a question of standing a siege or continuing the war in the open. Owing to the action of the Allies, the fortress was held long enough to show that the forts, like those of Liége and Namur, had not been constructed to be proof against the weight of metal brought against it by the Germans. The outer line of forts fell rapidly, smashed by the German heavy artillery. A field position on the line of the Rivers Nethe and Rupel was successfully held far longer by the Belgian Field Army and the British Naval Brigade, and was abandoned rather to avoid isolation from the Allied Armies than by the direct assaults of the enemy.

However, as a pivot of manœuvre for the Belgian Field Army in their threats against the German right wing, it proved effective for a time, and was thus responsible for containing an important detachment of the German Field Army till after the Battle of the Marne.

Bucharest, the fortifications of which were constructed in 1880 to the plans of Brialmont to meet a Russian threat, was evacuated as a result of a linear battle in the foreground, and so proved of no value.

In the Marne crisis, Paris was evacuated by the Government, and, therefore, as a refuge and a protected capital, the fortress failed to fulfil the object for which it was designed. On the other hand, as one of the pillars of the defensive line, Verdun–Rheims–Paris, it fulfilled a purpose for which it was not primarily intended. The fortress itself was badly out-of-date and, if attacked, would have depended chiefly on the field fortifications constructed under the orders of Gen. Gallieni, though the latter also took steps to strengthen and modernize the permanent works then existing. Thus, we see, that no fortress designed to fulfil a rôle independent of other fortresses or the field army successfully achieved such an object. We must, therefore, pass on to consider fortresses, organized for all-round defence, but included in a linear battle system.

The first system to be considered are the defences of the Belgian Meuse, including the fortresses of Liége and Namur. Their object is

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explained by Lord Sydenham in his report on the Belgian defences in 1890. "It is not the protection of Belgium against invasion," he says, "which is directly sought, but the closing of a route connecting the territory of two other powers, who, it is assumed, must, sooner or later, be again at war, and either of which might select this route as offering advantages in striking at the other . . . If, however, Belgium possessed an effective field army capable of being rapidly mobilized, the strategic value of the positions of Liége and Namur would assume far greater proportions."

Actually the Belgian official description of the fortresses was that they were "*simples pivots de manœuvre, des places d'arrêt.*"

Lord Sydenham pointed out that the minimum garrison for these two fortresses amounted to 53,000 men out of a total mobilizable strength of 80,000. Therefore, if the fortresses were properly garrisoned an altogether insufficient Field Army would be available to co-operate in the defence of the line of the Meuse. In matter of fact, the active troops were removed from Liége before the attack, leaving only troops of low category, insufficient in numbers to man the perimeter. At the same time the permanent works had only been designed to withstand 21-cm. shells, while it was known that pieces of considerably greater calibre had been used against Port Arthur ten years before, and that the Austrians possessed considerable numbers of 42-cm. howitzers.

In consequence of the weakness of the garrison of Liége the intervals between the forts were penetrated by the German infantry attack on August 6th, and the citadel captured. Even so the forts thus isolated held out till August 16th, and thus, at a low estimate, delayed the German advance for about four days.

The Belgian Field Army thus at an early stage ceased to act in co-operation with the fortresses for the defence of the Meuse, and withdrew on to the line of the river Cette, with their right resting on Namur, and with the great buttress of Antwerp in their left rear. The defences of Namur, before which the Germans arrived on 19th August, were in a similar condition to those of Liége. The Germans opened fire on 21st August with heavy howitzers, and the fortress was abandoned on the night of 23rd–24th August, as five out of the nine forts were reduced to ruins in the first 24 hours' bombardment.

The value of the four days thus gained can, to some extent, be realized when one remembers that on 20th August the French 5th Army had not completed its change of front and had only two corps on the River Sambre, while the B.E.F. had only that day completed its concentration. While the value of the four days' grace cannot be underestimated, the credit for the delay cannot be claimed solely by the permanent defences, though the fact of their existence marked beyond doubt the importance strategically of the position.

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The towns of Langres, Dijon, Rheims, Laon, La Fère and Lille were all ring fortresses not joined up by permanent works, but so placed as to become the keystones of a defensive position. The lines Belfort–Epinal and Toul–Verdun were so joined up in peace.

The first of these lines, that from Langres to Lille, was not so up-to-date, nor so well armed as were the latter two. The fortresses in that line had been neglected, and, in fact, the policy of the maintenance of the majority of French fortresses had not been fully co-ordinated with the plans of the Field Army. The line was turned because the fortresses of the Meuse failed to restrict the enemy's turning movement, also because General Joffre did not realize at this time the seriousness of the outflanking movement, and so did not move troops to oppose the German right flank armies in co-operation with the northern fortresses. The four northernmost of the fortresses of this line were, therefore, abandoned without offering any resistance.

It is here of some interest to consider what the effect on the course of the campaign would have been if, with the help of an adequate Field Army, the Belgians had been able to hold the line of the Meuse. The German flanking movement would then have failed or have been limited to routes south of the Belgian Meuse. Would it then have been able to break frontally through the line of French frontier fortresses, which by this time could have been covered by an allied Field Army? This operation would have been rendered especially difficult by confinement of the invading forces in the difficult Ardennes country, and the loss of the more accessible routes closed by the defences on the River Meuse.

Of the more up-to-date lines Belfort–Epinal, and Toul–Verdun, the former was never closely attacked, though it formed the base for the successful First Army defence of the Trouée de Charmes.

The northern line was attacked and, though pierced, never gave way. The left flank of this line rested on the fortress of Verdun, and the operations for the attempted capture of this town form the most important item in the history of fortification in the whole war. The trace and design of the fortress was not absolutely up-to-date, but the works had been strengthened to withstand the fire of the heaviest pieces of artillery then known, and it is claimed by French military writers that no gun turrets or armoured emplacements in this fortress were put out of action permanently by shell fire. To what extent the successful defence of Verdun was due to its permanent works will remain open to question. It can be pointed out that the defence of the field defences of the Mort Homme was as successful as that of sectors which were more closely covered by permanent works. There can, however, be little doubt that the moral effect of the presence of these permanent works assisted considerably in the stubborness of the defence. But more especially

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the existence of a properly organized system of field defences contributed to the successful retention of the position.

From the strategic point of view, the retention of Verdun by the French, in conjunction with the active operations of General Sarrail's Army in August and September, 1914, during the Marne crisis, is probably of greater importance than its defence against the concentrated efforts of the Crown Prince's Army in 1916. The salient caused by the defence of Verdun hung up the advance of the German 5th Army, and drew their 3rd and 4th armies far to the east of their allotted axes of manœuvre. To this cause may largely be attributed the gaps on either side of Von Bülow's Army, and the change of direction of Von Kluck.

The defence of the line Toul–Verdun and of the heights of the Meuse at the same time finally put a stop to Von Moltke's plan of double envelopment.

Two other French fortresses must be mentioned, Besançon and Maubeuge. These were ring fortresses in advance of the main lines already referred to. They were designed to draw on themselves a part of the invaders' effort should it be condensed on a wing, and to control certain communications which might otherwise be useful to the enemy if he pushed forward on those flanks. Both these fortresses were badly out-of-date, and the policy of the French Government as to their status had not been clearly defined.

Besançon was never attacked. Maubeuge, the totally inadequate details of whose permanent defences were clearly brought to light in General Fournier's trial, was garrisoned by about 40,000 men of low category, and was provided with few guns. The energy of the commander had produced, when the siege commenced, a ring of field defences between the permanent forts, well provided with means of communication. The fortress thus improved withstood the German assaults for eleven days, and thus during the critical period of the Battle of the Marne closed certain railway communications to the Germans, and also contained two complete army corps of the German Field Army, which might have proved of decisive importance on the Marne. On the German side, Thionville, Metz and Strassburg formed a line of fortresses which were to be joined up by field positions on the outbreak of war. Even without these field positions it was considered that penetration between the fortresses would so constrict a French attacking army as to endanger its safety. As none of these fortresses were ever attacked, their practical value was not tested, but their existence and also that of the French fortresses had undoubtedly a very great limiting effect on the plans of campaign of the respective combatants at the beginning of the War.

The German march through Belgium was, undoubtedly, due in large measure to the natural and artificial strength of the French

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Frontier, while the action of the French armies under plan 17 depended largely on the effect of the Fortress of Metz.

Turning to the Eastern Front, Russia had adopted a different system of frontier defence. A barrier of fortresses was constructed on the general line Grodno, Ossoviets, Ostrolenka, Novo Georgievsk, Kosensi, Ivangorod, Lyublin, Kholm. East of this line the country was fully developed with main roads and strategic railways. West of the line a zone of undeveloped country, with few main roads and practically no railways, was maintained up to the Austro-German frontiers.

The object of this undeveloped zone was purely defensive, and to render any invasion of the Polish Salient a very difficult matter. The result was that, when the Russians wanted to assume the offensive on this front, the attempt broke down owing to the difficulties of an advance over this "desert area." The Germans on the other hand, owing to their superior equipment and organization, succeeded in advancing to Warsaw over this area.

Before the War the Russian fortresses along the Eastern edge of this undeveloped region were quite out-of-date and their armament almost useless. The Russians, therefore, did not rely on them and actually, in the case of Ivangorod, when attacked, they took the guns out of the forts and placed them in new field positions in the foreground. Here they took the Germans by surprise and effectively checked them.

On their Eastern frontier the Germans had fortified the line of the Vistula, from Thorn to Elbing. They intended, if necessary, to surrender the rich country of East Prussia till a decision had been gained in the West. Actually this line was never attacked, for, though Von Prettwitz had commenced the withdrawal of the forces in East Prussia on to this line of fortresses, the plan was countermanded when Hindenburg took command of the German forces in this theatre.

It is open to question, however, whether strategically the original plan of reliance on the fortified river line was not the correct one. The adoption of a forward policy led the Germans to send important reinforcements from West to East before a decision in the Franco-Belgian theatre had been reached. A potent factor leading to the decision to adopt the forward policy was undoubtedly the pressure of public opinion against the voluntary surrender of German soil to the invaders. This is a point of view that may, in the future, press for the protection of strategically unimportant areas and may, therefore, largely affect the siting of fortresses.

Actually a forward line of fortresses did exist about Königsberg, Lotzen and Nikolaiken, through the Masurian Lakes. This line was attacked and pierced by the Russians under Rennenkampf, but the success was limited, as the fortresses of Königsberg and

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Lotzen never gave way, though the latter was seriously threatened from 23rd August, 1914, to 4th February, 1915. This was a small fortress relying chiefly on a strong line of field defences flanked by the lakes.

Königsberg succeeded in containing a relatively large detachment, two Russian Army Corps, from the battle of Tannenburg.

The Austrian fortresses of Lemberg, Przemysl and Cracow formed buttresses of a defensive line facing the Russian frontier in Galicia. They were also situated astride the only railway running east and west between the Russian "desert zone" and the Carpathian mountains. They, therefore, formed a barrier line against Russian aggression from the Polish Salient, and also a succession of barriers against a Russian advance from the east.

Cracow was never attacked. Przemysl sustained two important sieges. The fortress in 1914 was hopelessly out-of-date, both in design and strength of works, and in armament. In the first siege, which lasted from the Austrian retreat on 18th September, 1914, till the relief achieved by the Austrian counter-offensive on 9th October, the Austrian garrison consisted of 61½ battalions, the majority of whom were second-class troops, 7 squadrons and 16 field-guns. These contained a Russian force of 150 battalions, 48 squadrons, and over 500 guns of the Russian Field Army, and also effectively blocked the main Line of Communication of the Russian force operating against Cracow. It was due to the offensive spirit of the commander of the fortress that such a large Russian force was contained, and the operations were rather of the nature of field than siege warfare.

The Russians, owing largely to their self-made "desert zone," were unable to get up heavy guns for the reduction of the fortress, and in three attempts to capture it by *coup de main* suffered 70,000 casualties. In the period before the second siege the stores of the fortress had been largely drawn on to supply the Field Army. In the second siege which commenced on 5th November, 1914, the garrison was of approximately the same size as in the first, but contained a force only about half as strong as that used against it before. The defence was again carried out with great vigour, and depended in the earlier stages on a newly-constructed field position well in front of the permanent works. After four-and-a-half months the garrison was forced to capitulate owing to disease and starvation.

When the Austrians advanced again in May, 1915, the fortress fell in four-and-a-half days, though the Russian defenders were told to hold out to the last extremity.

Lemberg was never defended; on each occasion it was evacuated by both Russians and Austrians without its isolation from the Field Army being awaited.

Owing to the static nature of the warfare on the Western Front

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the battle-line gradually approximated to permanent fortifications in so far as that much time and material were available for its organization. In the battle-line, however, certain areas were afforded special treatment, where their loss would endanger the rest of the line, or their retention would ensure the safety and inviolability of the front.

Examples of such areas may be given as far as the German defences were concerned in the Paschendaele Ridge, the Wytschaete-Messines Ridge, and the Aubers Ridge. The complicated and permanent nature of the defences built up by Germans in the case of the last-named is clearly shown by the report on those defences prepared by Major B. T. Wilson, D.S.O., R.E.

A similar example on the British side may be mentioned in the area Kemmel-Mont Rouge. Owing to the lack of previous and unimpeded preparation these areas relied more for their defence on troops than on fixed material, and, therefore, could not carry out that essential principle of economy to the extent that might be achieved where time is unrestricted, and enemy action does not interfere with work.

From the above study certain lessons as to the use of permanent fortification from the strategic point of view stand out clearly. The first of these is that fortresses are generally useless, if not actually wasteful, if they are not designed to be mutually supporting, or to be defended in connection with the operations of a Field Army. Hence follows a corollary that the siting of fortresses, if constructed, must be in close relation to the accepted plan of campaign of the national forces.

The value of fortresses can only be judged by their effect on the operations of the field army. If they can still be relied upon to economize men on the defensive front while the decisive blow is struck elsewhere, if they can contain relatively large numbers of the enemy at a moment when the commander of the field army is ready to strike his decisive blow; if fortresses can gain the necessary time or sufficiently restrict the liberty of action of the enemy so as to allow of the development of the plan of the field army commander, then, indeed, permanent fortification must still be practised. Does the experience of the Great War suggest that fortresses can carry out these objects? The above investigation would seem to show that they can. Did not the presence of Metz and Strassburg allow the Germans to economize men in order to add weight to the decisive blow by their right wing, even more than Von Moltke actually attempted to do? Antwerp, Maubeuge, Königsberg and Przemysl, all contained relatively important forces away from what might have been decisive battles on the Marne, at Tannenburg and in Western Galicia. Namur gained time for the Fifth French Army to complete its change of front. Paris and Verdun in 1914, as well as Verdun

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and Rheims in 1918, restricted the liberty of action of the German forces advancing between them, and left them vulnerable to counter-strokes. It would seem clear that certain areas, selected in time of peace for defence, did in a great degree fulfil the ideas which prompted their selection, and for one purpose or another gained time for the action of the field armies. It would, therefore, seem to be a fair deduction that, in future wars, certain areas will be selected beforehand for defence, for similar reasons. Whether they will be provided in time of peace with permanent works as at Verdun, or be organized for a defence after the outbreak of hostilities, like Ypres, is a matter which calls for further consideration.

The above investigation of the experiences of fortresses in the Great War would seem to indicate that they relied chiefly for their success on field fortifications rather than on permanent works constructed in time of peace. This does not prove, however, that the existing works were suitable for the type of warfare experienced, and it is possible that other works prepared in time of peace would have been of value in adding to the strength of the defence.

It may be argued that the progress in scientific warfare will tend to neutralize the value of permanent works ; and that the increased range and shell-power of artillery and the improvements in aircraft, gas and tanks will make the defence of fortresses more difficult. This is certainly true if the design of the fortress itself does not march with the times, and this has been the difficulty in the past, and is likely to continue to be so in the future. The works of a fortress once built can only, to a limited extent, be altered to meet changes in weapons. But experience in this and other wars has shown that works reasonably up-to-date can be of great value, and in our investigations we must, therefore, endeavour to discover if there are any works which can be best constructed in peace which will be likely to be of value in a war twenty or thirty years hence ; otherwise it will not be worth while constructing them.

The increase in power of artillery made very noticeable progress during the war, but, on the whole, the increase in range was more noticeable than any increase in the disruptive effect of the projectiles. From the general point of view of tactics, increase in range of artillery will favour the defender rather than the attacker, and fully-organized defences prepared in good time will enable the defenders to make the best use of their heavy long-range artillery. Defences, including communications, organized beforehand imply permanent fortifications in some form or other. The experiences of Verdun showed that the latest works were proof against the shells fired against them, and, therefore, at the moment no great advance in strength of material would seem to be necessary. The fortifications of immediately pre-war days depended largely on concealment and inconspicuousness for their immunity from enemy destructive fire.

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The "*Feste*" system of Metz, as opposed to the closed works of the French Frontier forts, was introduced largely with this object. It has been argued that the advance in air power has rendered the concealment of permanent works impossible, and that, therefore, permanent fortifications will be exposed to a better-directed destructive fire from artillery and air forces. The counter to this air-directed fire, as the static period of the Great War continued, was found in concealment, in tunnelled dug-outs and communications, or concrete works nearly flush with the ground and hidden during construction by carefully arranged camouflage. Tunnelling is always a lengthy operation, and surface works, no matter how much care is expended on their concealment, with difficulty avoid recognition. The other method of avoiding observed enemy fire is improved mobility. Mobility depends on efficient communications, roads, railways, or subterranean passages. All these, in the mobile period of operations which must occur before the decisive moment, can only be available if prepared beforehand. The less passive anti-aircraft defences, including guns, searchlights, and aeroplanes, depend chiefly on carefully co-ordinated action, which demands very efficient communications. A study of the air defences of areas of importance, like London, during the Great War, will clearly indicate that efficient anti-aircraft defences cannot be improvised quickly where no previous preparation has been made. The introduction of gas has been said to make impossible the defence of comparatively confined areas, and it must be foreseen that a previously prepared defended area will form the target of large concentrations of gas delivered by artillery, in clouds, or possibly from the air. On the other hand, previously prepared works permit of the existence of proper gas-tight doors, efficient ventilation, including the supply of fresh air pumped possibly from a distance, and all known means of anti-gas protection. Nor is it very far beyond the realms of reason to foresee the discovery by chemists of neutralizing vapours or gases which, combining with poison gases, will render them innocuous. Such counter-gases could most easily be stored and made use of in works constructed before an immediate call for them arose.

The ideas of the futurist who thinks of war in terms of tanks and their effect on the design of permanent fortifications must not be lost sight of. Measures to resist tanks may be classified under two headings, offensive measures, the chief of which is the gun, whether mounted on another tank or otherwise; and defensive measures, which include obstacles of all kinds and minefields. The use of obstacles and fire weapons must always be closely related. The prime object of the obstacle is to drive the attacker into positions from which he can best be dealt with by the fire weapons of the defence, at the same time obstacles should not interfere with the counter-offensive action of the defenders.

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Improvements in tanks, present and future, will enable them to cross considerable obstacles both excavated and erected. In fact, these obstacles must in future be of such dimensions that they must be prepared before they are required. Such obstacles, as well as direct-acting minefields, will interfere considerably with the action of friendly tanks. Where previous preparation is possible, electrically-controlled minefields could be constructed which would allow of the passage of friendly tanks while denying that of enemy tanks. As far as one can see at present, the gun will remain the principle offensive anti-tank weapon. Previously prepared shelters will give immunity from artillery fire and from aeroplane bombs to the gun-bearing tanks of the defence, while concealed and armoured works can be constructed to protect the anti-tank guns not so carried. It will appear evident from the above considerations that, if it is considered advisable to mark down in peace certain areas of strategic importance, whose retention will prove of value in assisting the operations of the Field Army, there are certain works in connection therewith which can best be constructed in time of peace. Some of these works have been suggested by our investigation of measures to be taken to meet certain weapons of the attacker, but the list is by no means exhausted; before considering them in more detail it will be advisable to consider the general design of these fortified areas or fortresses. It has been clearly shown that fortresses must be selected and designed so as to co-operate in the action of the Field Army. While fortresses eventually isolated such as Antwerp, Maubeuge, and Przemysl did produce a distinct effect on operations, the effect would, undoubtedly, have been greater if they had co-operated more closely with the Field Army itself, as in the cases of Verdun and Paris, in 1914. The areas selected as fortresses will then normally be interdependent, so as to form barriers to the advance of hostile armies. The line Verdun–Toul with the fortifications of the Heights of the Meuse was probably the most completely successful example of such a form of defence, but the buttresses of Verdun and Paris to the French line at the beginning of September, 1914, and those of Verdun, Rheims, and the Forest of Compiègne in the summer of 1918, when three and a half years of trench warfare had allowed these areas to be turned into strongly fortified localities, permitted the Allied line to bend without giving way, and by preventing the German Army widening the base of the salients of their advance, restricted its liberty of action and eventually brought it to a standstill and left it open to the counter-strokes of Gallieni and Maugin.

These last examples demonstrate that it is not necessary for the line to be continuous, but that the fortified buttresses should be at sufficiently close intervals to attain this object of restricting the enemy's advance.

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Within the limits of achieving this object, the wider the spaces between the fortresses the more will the principle of economy be achieved. The failure to balance the needs of the Field Army with the necessities for the garrisoning of the fortresses is shown by the Belgian defence of the Meuse fortresses in August, 1914.

Examples may still occur of the value of isolated fortresses. Such may be illustrated by the fortress of Adrianople, which, in 1913, blocked the only line of advance of the Bulgarian Army against the Turks, who were reforming their forces behind the Chatalja lines. With the growth of networks of railways, such instances will become fewer, as was foreseen by Moltke when he said "Build no more fortresses, build railways."

The fortresses of the future would, therefore, seem likely to be in the form of buttresses which should not in the first instance be expected to be completely surrounded; though such an eventuality must not be entirely neglected.

The buttresses should be wide at the base so as to avoid the danger of being pinched in the same way that the Field Army, working in conjunction with the fortresses, hopes to pinch the base of the salients formed by the enemy's advance.

We shall, therefore, expect the fortress to be *parabolic* in form with a "gorge" protection across the base in case of isolation.

With regard to the nature of the permanent works within the fortress we have an excellent guide from Lord Sydenham, who, writing in 1892, said, "Organization, capable commanders, efficient armaments, adequate supplies, matured preparations, well-arranged communications, these constitute the essence of defence." It will be noticed Lord Sydenham places "organization" first, and that proved certainly the experience of the Great War. Organization depends in modern warfare chiefly on communications and mobility; without these there can be little co-operation between the various parts of a force, which would otherwise lack flexibility and become a wooden automaton.

The first essential in the modern fortress will, therefore, be invulnerable communications, and rapid and covered means of movement. The framework will, therefore, be protected signal communication, whether buried cable, protected wireless installations, or subterranean passages, added to complete tram and railway systems for moving guns, personnel and munitions. These trams and railways will also, very likely, be all underground, partly for protection and partly for concealment from air observation. These tunnels will be protected from poison gas and will also afford a means of supply of fresh air to shelters and gun stations.

Before the outbreak of war it is unlikely that there will be much in the way of works visible on the surface, save large numbers of shallow concrete "pill boxes" for fighting troops, machine-guns

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guns or tanks dotted about on an apparently irregular plan. This would follow the ideas of the German engineers who in the new positions built in front of Metz during the war had as many as 800 concrete pill boxes on a front of two or three kilometres. Anti-tank obstacles and electrically-controlled minefields will also be an important adjunct prepared in peace.

Colonel Lévêque in a series of articles in the *Revue du Génie Militaire*, in the autumn of 1922, gives his ideas of the future design of fortifications, and in them he adds to the works already mentioned above armoured gun positions. It is certainly open to question whether guns are not better protected by concealment and mobility, and it would certainly seem that the larger proportion of the guns should be mobile, either by rail, road, or on cross-country tractors. The experience of the comparative invulnerability of the gun emplacements at Verdun might lead some to consider that a certain proportion of the guns might be mounted in armoured works, especially where these can be concealed. But before including such works in the fortresses of the future, the eternal struggle between gun and armour must be seriously considered. The work that is proof against the shells of 1924, may be useless against the projectiles of 1944. It is probable, therefore, that only in very exceptional circumstances will such works be constructed.

It is essential that all alternative positions for guns should be connected up by protected signal systems to concealed and protected observation posts, without which the value of the guns is very small. The speed of modern aeroplanes and their rate of climbing will make it generally advisable for the aerodromes of machines working in connection with the defence of the fortress to be accommodated outside the fortified zone. Further, as the defence and attack of a position will depend more and more on air action, an enemy determined on the reduction of a fortress will generally first concentrate his attention on the aerial defence of the fortress. The provision of bomb-proof hangars for the defending aeroplanes will, therefore, be necessary, and on a scale quite impossible in field operations. Such may, therefore, in general terms be the nature of fortresses or fortified areas which will be prepared in time of peace in the future. The arrangement of these works, and the details of their construction, are matters which cannot be discussed in one article. The objection may be raised that money will not be available for the construction of such works, and it is certain that it will always be difficult, in time of peace, to get all the money required for military needs. That being the case, the soldier will very rightly argue that all the limited resources should be devoted to the production of a Field Army of the highest efficiency. The soldier must always press for this, but it must be faced that in these days of democratic government it will be more possible to get money

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voted for purely defensive purposes, and not for purposes which can be suspected of aiming at "Imperialistic conquest." Possibly also public opinion will demand material measures for the protection of important industrial areas. The French Commission's investigations into the surrender of the Briey coalfields in 1914, are an indication of what may be demanded in the future with regard to the protection of such areas. Even if the areas themselves are not directly fortified, the necessity for forward concentration of the Field Army may demand defensive lines close to the frontier.

Added to this it may be pointed out that the expense of permanent fortification is comparatively small. The total expenditure by France on the defences of Verdun and the heights of the Meuse between the years 1874 and 1914, did not exceed the cost of two battle cruisers—not a great expenditure for blocking one of the main lines of advance into France and for forming a pivot on which the French main plan of campaign could depend. Frontiers may be uncertain and national finances low at present, but it would seem probable that the future will see permanent fortification, somewhat on the lines suggested, reappear. It is important, therefore, that we should follow the trend of European thought on the subject, even though we may only be concerned directly with the construction of coast defences which lie outside the scope of the present article.

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HOW TO WRITE A LETTER.

By MAJOR G. E. H. SIM, D.S.O., M.C., R.E.

FIFTY years ago letter-writing was an art. One has only to read some of the collections of " letters " of celebrities (and others) that have been published of recent years to realize the amount of care and thought that must have been expended on their composition Nowadays the writing of a letter is, to most of us at any rate, an uncongenial labour. We take little pride in the composition of a " good " letter, nor are we ashamed of producing a " bad " one. When we die nobody will bother to publish a collection of our letters, and if they were published nobody would bother to read them.

Many are the causes which have gone to produce this state of affairs. The telephone and telegraph, to say nothing of the improved means of locomotion of the twentieth century, render much of the old letter-writing unnecessary. The ubiquity of newspapers and their correspondents has, to some extent, superseded the dissemination of news in letter form. In these hurrying times, moreover, people have little leisure to devote to writing letters: they play bridge instead.

The result is that many people in these days never write a letter if they can avoid doing so. They get no practice in the art of letter-writing and, as a result, are often incapable of expressing themselves intelligently on paper.

But every officer, especially every Engineer officer, should be able to write an intelligent letter. It is surprising how few of them can. All officers have to conduct official correspondence, and at each step in rank they find that a greater proportion of their time than before is spent at an office desk. Many officers affect to despise " paper." To do so is a mistake. Paper at its worst is a necessary evil, and it only becomes an evil when something silly has been written on it. Paper at its best (*i.e.*, intelligently used) may be compared to the nervous system of the body, which conveys the thoughts of the brain to the muscles, and the sensations from the surface of the body to the brain. On the intelligent use of the available means of communication, of which the writing of letters is by far the most important, depends the smooth working of the army machine in all its functions, operations, training, administration, etc.

Our military text books have much to say about the writing of

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orders (which really constitute a particular form of letter), but little, if any, help is given to the officer who wants to learn how to set about writing a letter. King's Regulations lay down the *form* in which official correspondence is to be conducted, but one looks in vain for any guidance as to its *substance*. And it is the substance of a letter that really matters.

Every letter, apart from orders, with which it is not proposed to deal, is written with one of two objects :—

Either the addressor gives information to the addressee which will influence the addressee's course of action,

Or the addressor asks the addressee to furnish information which will influence the addressor's course of action.

Letters may, from another point of view, be divided into other categories, namely, original letters and replies.

A third division may also be adopted, namely, letters to superiors, equals and subordinates.

It is not, however, proposed to discuss all these divisions and cross-divisions in detail. They have only been mentioned because the first requirement of a good letter is that the writer should be perfectly clear in his own mind to whom and about what he is writing. The first thing the writer should do, before putting pen to paper, is to " categorize " the letter in his own mind—*e.g.*, " A letter to my subordinate calling for a report regarding the prevalence of rats in his barracks," or " A letter to my superior, in reply to a letter from him, reporting on the state of my mobilization equipment," or " A letter to my superior offering suggestions, unasked, regarding the new system of accelerated promotion of N.C.O.'s."

Having thus indicated the main categories into which official correspondence may fall, we will now proceed to examine certain points which are common to most forms of correspondence and which require the careful attention of the writer if his letter is to fulfil the purpose with which he writes it.

Justification.—When you think of writing a letter, first decide whether it is necessary to write it at all. If it is a letter giving information, ask yourself whether it will be the least use to the addressee when he gets it. If it is asking him for information, make sure that you really want the information, and, if you decide that you do, ask yourself whether the information required is not already in your possession or easy to obtain without bothering him with a letter. Judged by this test the proposed letter may be found to be quite unnecessary, in which case it should be left unwritten. Never write a letter unless it is going to serve some useful purpose. Even if you have nothing better to do than to write useless letters, it is probable that the addressee has something better to do than to read and answer them.

Accuracy.—Having decided that the letter must be written, the

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next thing to do is to be sure of your facts. This is especially important in respect of facts of which it is your duty to be cognizant. In this connection it must be remembered that it is your duty to be cognizant of all regulations, more especially of those applicable to your particular duties. A letter based on ignorance of regulations is quite useless. If the addressee is as ignorant as yourself your letter will mislead him. If he knows his regulations he will point out your error and you will look foolish. The same applies to any other kind of fact.

Truth.—Having marshalled your facts, you then have to decide how to use them. The one golden rule is : never, under any circumstances whatsoever, wilfully make a misstatement, or a statement calculated to mislead the addressee, in official correspondence. It is very easy to do and is often done. When one is very keen to persuade someone to do something which he is disinclined to do, one is very apt to suppress facts inimical to one's argument or to exaggerate facts in support of it. One may even be tempted to make a deliberate false statement. This is immoral. Furthermore, it is highly dangerous. The chances are that you will be found out and, apart from the direct consequences to yourself which matter only to you, your argument will be entirely vitiated and spoilt by that one small exaggeration or falsehood. Be honest. Be truthful. If your case is good it needs no *suppressio veri* or *suggestio falsi* to bolster it up. If it is bad it is not worth arguing about.

Relevance and Completeness.—Decide what is relevant to the subject under discussion and put it in. Cut everything else out. Your addressee is probably a busy man who will not appreciate long dissertations on matters which, though interesting in themselves, have little or no bearing on the question under discussion. The inclusion of irrelevant matter in a letter is bound to obscure rather than clarify the argument. Stick to the point.

Completeness is the complement of relevance. Confine your remarks to those that are relevant, but make sure that you do not leave out anything which is really essential to the subject. This point can best be appreciated if we take a concrete example. Suppose you are a Company Commander and the M.O. i/c Troops writes and asks whether Sapper Brown has been inoculated against enteric. You look up his record and find that he was inoculated against enteric at Aldershot on 17th September, 1918, prior to proceeding to Egypt. What should your answer be? It could be one of the following :--

(*a*) Yes.
(*b*) Yes, on 17th September, 1918.
(*c*) Yes, on 17th September, 1918, at Aldershot.
(*d*) Yes, on 17th September, 1918, at Aldershot, prior to proceeding to Egypt.

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Answer (*a*), though literally true, is not complete. In fact, it is positively misleading, as the effect of the inoculation has long ago worn off.

Answers (*c*) and (*d*) contain irrelevant matter. It is of no interest to the M.O. to know where he was inoculated, still less is he interested in his subsequent movements.

Answer (*b*) is correct because it contains all the M.O. needs to know and nothing that he does not need to know. It is relevant and complete.

All cases are not as simple as the above. Sometimes it is very difficult to decide whether certain matter is relevant or not, and whether or not it is necessary to include it for the sake of completeness. The best plan is to put yourself in the place of the recipient of your letter and ask yourself whether the inclusion of the matter about which you are in doubt will help him. In doing this it is safest to assume that the recipient is just one degree less intelligent than you really think he is. It is better to include matter which he already knows than to exclude matter of which he is ignorant and about which knowledge on his part is essential. Your grandmother will rightly resent it if you try to teach her to suck eggs, but she will think you are a nicely-brought-up young man if you pass her the salt, even though there be a salt-cellar within her reach.

Courtesy.—Always be courteous. Never be rude. It is sometimes difficult to suffer fools gladly, and when somebody does or writes something which we think particularly stupid we are sorely tempted to write discourteously. It never pays to do so. If you are discourteous to a subordinate who cannot retaliate you are not playing the game. If you are discourteous to a superior you are asking for trouble and will probably get it. Courtesy and politeness cost nothing and you are more likely to attain your ends by these means than by curtness and hectoring. In this connection it is well to remember that sarcasm is usually resented more than any other form of discourtesy.

Promptness.—Closely connected with courtesy is promptness in replying to correspondence. If somebody, whether he be your superior or subordinate, asks you a question it is only common courtesy to answer him at once. If you do not know the answer tell him so. If you do not know the answer, but, given time, can find it out, tell him you are making investigations and will forward a full report by a definite date. All well-conducted business firms make a point of answering all letters within twenty-four hours of receipt. It is a pity that this custom does not obtain in the Army. If it did, the amount of correspondence in most offices would be at least halved. It would be interesting to know how much public money is expended yearly in the Army on the postage of "reminders." If everybody did his job properly there would be no such thing as a reminder.

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Humour and Slang.—Official correspondence does not, as a rule, lend itself to humour. One is dealing with serious matters, such as Sapper Jones's dentures or the soot-producing properties of Government coal, and humour is out of place. Furthermore, however proficient you may be as a humorist, it does not follow that the recipient of your letter is blessed with a sense of humour. Slang also is to be avoided as a rule. There are plenty of good English words and phrases with which to express your meaning without having recourse to slang, which is usually American and often vulgar. Both humour and slang may occasionally be used to drive a point home, but they should be used very sparingly and with great care. A definite purpose should always underlie their use. Never be funny for the sake of being funny. Never use slang because you are too lazy to look for an English word or phrase in which to express your thoughts.

Balance.—A letter, to be a good letter, must be well balanced. In this respect a letter may be compared to a picture. The artist decides which parts of the landscape have to be emphasized and which merely suggested: where much detail is required, and where little or none. The result is that the person looking at the finished picture sees just what the artist means him to see. The important points catch the eye; the minor points, though there in the picture, merely serve to amplify the important ones or to make them stand out. So it should be with a letter. The letter, when written, should be a "complete whole," comprising a number of "features," to each of which its correct "value" has been given. The amount of "detail" required will vary with the type of letter, but it must never be allowed to obscure the main points you are trying to make.

Paragraphing.—It is often convenient to divide a letter up into paragraphs. If the letter is a long one on a complicated subject, paragraphing is almost essential. Each paragraph should, where possible, contain one "feature" and one only. Paragraphing will be found a useful method of emphasizing the "features" of a letter. The addition of a heading to each paragraph will add to this emphasis. Numbering your paragraphs, besides adding further emphasis, will facilitate reference. It requires less literary skill to write a letter on a difficult subject in paragraphed form than in the unparagraphed form in which the leading articles of newspapers are usually written.

Style.—One does not have to be an artist to produce a useful and intelligent military panorama sketch. One does not have to be a literary genius to write a useful and intelligent military letter. It is, no doubt, true that a man with a literary gift will usually find it easier to express himself well in a letter than a man with no such gift. But the latter need not despair. The words required are few and simple. The expressions commonly used in official corres-

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pondence are more or less stereotyped and standardized. There are certain tricks of phrasing and expression which can be acquired with very little practice. One may even go so far as to say that flights of literary fancy are almost as out of place in official correspondence as are humour and slang. The simpler the style of your writing the easier it will be to understand. Obscure words, recondite phrases, classical quotations, etc., will not help you to persuade the Regimental Paymaster that Sapper Robinson's balance debit is really a credit. A sound argument, clearly expressed in simple English, will serve you best.

Conclusion.—It may appear that the writer has been inclined to lay down the law in no unmeasured terms. His excuse is that he has, for the past seven years, been employed on work entailing a great deal of very varied correspondence. During those seven years he has himself fallen many times into most of the traps against which he warns the reader. He hopes that the conclusions which he has drawn from his own experiences may be of some assistance to others.

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THE BIRTH OF A GREAT EXPERIMENT.

SOME OBSERVATIONS ON A TERRITORY THAT FOR THE PAST THREE YEARS HAS BEEN ADMINISTERED BY THE LEAGUE OF NATIONS.

By LIEUT.-COL. E. G. WACE, C.B., D.S.O., R.E.

DOWN in the "left-hand bottom corner" of Germany is a small tract of country to be painted a new colour on modern maps; if you walk the whole way round this tract of country you will only have walked some 300 kilometres, under 200 miles; but you will have walked that distance of the new European frontiers laid down by the Treaty of Versailles.

The country referred to is the "Saargebiet," to give it its local official title; the territory of the Saar Basin is the fuller title to be found in the Protocols laying down those frontiers. Its population is nearly a million, and it contains the famous Saar Basin coalfields from which its wealth and importance are derived.

When the war ended and France took a look round at all her damaged industries in the north, one of the most grievous sights, as the British Army well knows, was the devastated coalfields of the Pas de Calais. The damage done to the mines themselves was so serious that the most optimistic estimates foretold a period of several years before the pre-war rate of output could be resumed.

As compensation for this disaster, the French naturally turned their eyes to the rich coalfields of the Saar Basin, lying so conveniently close to their restored province of Lorraine. Justice demanded compensation in kind, and here was the coal close to their new eastern frontier.

There are Frenchmen to be met who will claim that the territory where the Saar coalfields lie should have been handed over to France for good and all; the frontiers of Lorraine, a little over 100 years ago, extended well beyond the Saar river, and it was only after Waterloo that Prussia and Bavaria extended their sovereignty to the frontiers of Alsace and Lorraine, as we now know them. If France was to benefit by the coal of the Saar Basin, she required some security and protection for those who were to work the mines or some guarantee for deliveries. What could be simpler, then, than to hand the country back to her?

This solution would not, however, have conformed to the Wilsonian principles of self-determination, and a compromise was found.

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While it could be claimed that historically the country had once been French, the fact remains that its great development has taken place during the past century and is due to German enterprise. The insignificant little market town of Saarbrücken of 1814, with its sister-town of St. Johann across the river, have developed into the important industrial and railway centre of 1914, with a population of over 100,000. Here and there, chiefly about Saarlouis, the town to which Louis XIV. sent his British prisoners to work, are to be found families that may be called French Sarrois ; but for these, the population is German and, as a result of the great development of Saar industries, to a considerable extent consists of immigrants from Westphalia and other parts of Germany.

The solution, then, for this country, whose coal was to be French, yet whose miners were German, was the practical application of the newest and greatest experiment of Europe : the administration of the country by the League of Nations. The Treaty of Versailles has given to France the absolute possession of all the coalfields of the Saar Basin ; to enable them to be exploited by the French without fear of interference or chicanery, the Saar Territory is governed by a Commission of five members, representing and appointed by the Council of the League of Nations.

This *régime* is to hold for fifteen years after the Peace Treaty, when the self-determination principle is to be put into practice, and a plebiscite is to be held. As a result of the plebiscite the League of Nations will decide whether the Saar Territory is to be restored to Germany, or handed over to France, or to remain under the administration of the League of Nations. Which of these three alternatives is the one to bet on is not easy to say ; the second seems, at present, to be the least likely ; the first is, at first sight, the " favourite," but there may be some hope for the third. The country is rich, and escapes the burden of Reparations ; when the customs revenue is at a normal figure the difficulties of the budget must be considerably lightened ; in short, the life of the Sarrois, given the continuance of good government, should be a peaceful and happy one. In such circumstances it does not seem to be too great a stretch of the imagination to see a reasonable degree of probability in the third alternative, resulting in a neutral independent State between Lorraine and the Rhineland.

It was evident from the start that the task of the Governing Commission was going to be no light one ; agents and propaganda from the " Heimatdienst " in Berlin formed an active opposition. The majority of the most efficient German officials in government services and departments had already been removed by orders from Berlin, while of those that still remained there were few who could be regarded as Sarrois. The unrest that was consequently stirred up in the various government services (railways, posts and

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telegraphs and the like) soon came to a head in a strike. The luck, however, was with the Governing Commission, for, before the strike was ordered, a German agent carrying important incriminating papers was discovered, by a fluke, by a French *douanier* at the German–Sarrois frontier, and the cat was out of the bag. A short spell of " state of siege," several deportations, and the issue of a wise and considered statement by the Governing Commission settled matters, and a period of tranquillity was introduced.

The country circumscribed by the frontiers of the Saar Territory corresponds to no single administrative area of pre-Treaty days; it includes portions of both Prussia and the Bavarian Palatinate. To the average German, indeed, living at a distance from this corner of the fatherland, it is doubtful whether " the Saar " connects with his mind anything other than wine; but even the Saar vineyards are not included in the Saar Territory, being situated lower down the Saar river below Mettlach. It is strange, in fact, how little is known even in Germany of the geography of those parts, since it is not a rare event for letters from Germans in Berlin to be addressed to " Saarbrücken, Alsace-Lorraine " !

Saarbrücken, the capital, is an unlovely spot; situated astride the Saar river, and shut in by hills on either side, it has a disagreeable atmosphere, tainted by coal-dust and the fumes from the great steel works on the outskirts north and south of the town. From the hills on the western edge of the town a fine view is obtained across the old German " Exerzierplatz " to the famous Rotheberg and the site of the battle of Spicheren of 1870. North from the Rotheberg, at the point where the frontier crosses the road from Saarbrücken to Metz, stands the inn called " Der Goldene Bremm," round the courtyard of which stand the iron railings still bearing the bullet-marks of 1870. About half-way between this inn and the outskirts of the town lies the new cemetery, in a portion of which are to be seen the graves of the allied soldiers, prisoners of war, buried here by the Germans; this portion of the cemetery is carefully tended by the French troops in Saarbrücken, but to British eyes the wooden crosses, with their misspelt inscriptions erected by the Germans, have a rather tragic air, seeming to emphasize the pathos of the worn-out prisoners of war, far from home and kindred. This feeling is not lessened when, passing from the wooden crosses over the graves of allied soldiers, with the bald " Hier ruht " at their head, followed by the name, rank and regiment, the visitor finds the graves of German soldiers and the inscription on their crosses, " Hier ruht in Gott."

There is, in Saarbrücken, one curiosity to be seen in a broad, much-used street in the centre of the town, which, to our British eyes, seemed to deny to the Germans their boasted characteristic of thoroughness. In spite of their hymn of hate, they had left up

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over a piano-shop a large British royal coat-of-arms, with supporters and motto, not a sign being evident on its gold-and-paint of the obloquy the Germans were hurling at our Royal House.

The frontiers of the Saar Territory were defined, on broad lines, in the Treaty of Versailles, their exact location being left to an international commission of five members, whose decision was to be final and binding on all the Powers concerned. The Commission was composed of a Frenchman and a German, as representing the two " interested " States, and three other nationals to be nominated by the League of Nations. The nomination of these three officers constituted the very first decision of the Council of the League.

The frontiers to be laid down were two, that between the Saar Territory and France, and that between the Saar Territory and Germany, or, more strictly, the rest of Germany; for the German claim is that the Saar has not renounced German sovereignty, but has been handed over to the League of Nations as trustee and administrator. The frontier with France is the old frontier between that country and Germany which was fixed after Waterloo and lasted till the War of 1870. The task of the Commission at first, as regards this frontier, appeared simple, but eventually proved to contain many thorns; the frontier Commission of 100 years before had taken some fifteen years over their task, and even then a host of discrepancies was brought to light by the more exact instruments and methods of to-day. In addition to these difficulties, which the Commission, after all, was competent to solve, were others arising from the fact that this old international frontier had, for the past fifty years, formed the boundary only between States of the German Empire. In such circumstances it is only natural that economic conditions on both sides of the boundary tended to merge, and to obliterate the results of the former separation; railways and large industrial concerns developed since 1870 naturally took no notice of the old frontier. In one case a railway station was found astride the old frontier, the main station building being in Lorraine and a certain small but necessary annexe on the Saar side; the great difficulty of such a situation was, of course, the regulation of customs inspections.

The other frontier, that between the Saar and the rest of Germany, was a new one; by the terms of the Treaty it followed in the north mainly along existing administrative boundaries; while in the east the same principle was applied as far as possible.

The Boundary Commission, which had held its first sittings in Paris, as soon as possible after the ratification of the Treaty, moved its headquarters in February, 1920, to Saarbrücken. The country, at that time, was under a French military administration, not very dissimilar to that in the occupied Rhineland. The arrival of the Allied members of the Boundary Commission passed almost

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unnoticed, but the arrival of the German Commissioner, resplendent in his military uniform, had a striking effect. By a singularly unfortunate decision of the French officer responsible for billeting, the German headquarters were fixed in an hotel in the main thoroughfare of the town, a street that throughout the day was packed with shoppers; the natural result was the collection of a crowd, anxious to stare again at a uniform so well known and yet banished for over a year! The excitement grew to such a pitch that the French authorities deemed it necessary to clear the street by a force of cavalry with swords drawn. The German Commissioner, whose status was equal with that of the rest of his colleagues, was entitled, like them, to wear uniform, but was prevailed upon to restrict the occasions for wearing it, and the excitement subsided. Later, however, as the result of further incidents, the German delegation appeared only in plain clothes; this change, apart from other reasons, had the advantage of avoiding the friction resulting from the question of saluting; the French soldiers must have felt an extraordinary distaste for saluting German officers, and probably *vice versa*.

The further incidents referred to above included a fracas at Zweibrücken, in the occupied Rhineland just over the Saar border, where the excitement caused by the appearance of the German Commissioner in his military uniform was similar to that caused at Saarbrücken; the crowd that collected round the Commissioner's motor-car was so great that it was some time before he could start, and in the meanwhile "Deutschland über Alles" was sung by the crowd; the singing was started, according to a French soldier's report, by the chauffeur playing this tune on his motor-horn! Germans are wonderful musicians!

Of the difficulties and discussions that arose during the deliberations over the final location of the frontier lines little need be said, especially in view of the fact that they have been solved and the frontier is definite and existing. They arose mainly through the attitude assumed by the Germans towards the German-Sarrois frontier, which they persisted in representing as a mere temporary arrangement to last only for the fifteen years during which the Saar remains under the trusteeship of the League of Nations. In accordance with this view the Germans had even proposed that this frontier should be marked by wooden posts; this, however was negatived by the Commission, and proper stone pillars erected. In the same way minor and insignificant adjustments of what were, in fact, only parish boundaries, were strongly opposed; these boundaries had been adopted as the general line for the frontier in most parts, with the idea of simplifying the administrative changes wrought by the creation of a new territory. But parish boundaries have little in common with a frontier, and offer no particular

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obstacles where properties or even houses are traversed by them, or in cases where a village water-supply is derived from the adjoining parish. But immediately these obstacles appear on a frontier the case is altered, and reasonable common sense aims at adjustments which will preclude the possibility of future disputes.

The conclusion is difficult to avoid that, from a political point of view, the Germans would have welcomed the persistence of obstacles and inconveniences resulting from the new frontier, in order, when the plebiscite is taken, to preach the advantages of its removal by the restoration of the territory to Germany. Certain of these difficulties were met by adjustments of the frontier line, and certain are being dealt with by means of *droits d'usage*, but even these measures are unable to reach the greatest difficulty of all. This lies in the fact that the Saar is mainly industrial and carries a large population for which its agricultural area is unable to provide. The farm land within the borders of the Saar is worked with the thoroughness that is to be expected of its people, but, even though to this thoroughness were added the scientific and systematic progressiveness of Canada, it would still be unable to produce the food required. This difficulty would have been sensibly diminished if those responsible for framing the Peace Treaty had taken a larger view of the needs of this small territory, and drawn their blue pencils somewhat more freely northwards and eastwards on the map.

At the office of the President of the Commission was a strangely cosmopolitan collection. The *secrétaire-général* was a French infantry captain, the register clerk was a Frenchman of Lorraine who, in the early part of the war, had perforce to fight on the German side, the typist was a Sarroise who had a smattering of French, and the caretaker a German, who, as ship's steward in pre-war days had acquired a few words of English. The official language of the Commission was French, but the correspondence with the local administrative authorities adjoining the frontier was in German, so that a knowledge of both French and German was essential. The French captain was a professional soldier, who had been severely wounded at Verdun; but, at the same time, Art, musical for choice, and not the military virtues of precision and orderliness, was his particular *forte*. His voice and his 'cello, with both of which he discoursed magnificently, were perhaps his greatest assets, and certainly his pride. To illustrate this, two stories must suffice. After performing one Sunday at Mass, when nearly everyone had left the church, he was approached by a man who introduced himself as an ex-officer of the German army; the latter thanked him profusely for the musical treat he had so enjoyed, and as a token of esteem, though he had never spoken to him before, offered him the Iron Cross which, he said, had been presented him on the field of battle. And the captain not only accepted it, but declared

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to all to whom he related the incident that he would treasure it among his most valued possessions ! The other story concerns a prominent mole on the captain's forehead ; a brother officer, chaffing him about this, said that it foretold pre-eminence, and that some day, doubtless, he would be a marshal of France. " *Tiens* ! " replied the captain, " there are six marshals of France, are there not ? While there are only five tenors like me ! " This reply may well have been made in chaff, too, but as to the former incident— ? Certainly music is international, and nothing could have been more enjoyable than a musical evening organized by the Japanese Commissioner in his rooms. Here the charming wife of a French major sang, the chief of the staff of the French troops in the Saar played piano duets with a French civilian of one of the administrative branches of the Saar Governing Commission, the German bass from the State Theatre sang " The Two Grenadiers " magnificently in German, while, to crown all this, the French captain, secretary-general of the Boundary Commission, sang duets from " Carmen " with the German prima donna of the State Theatre, he in French and she in German !

So much for the lighter side of life. What is to be said of its more serious aspect ? The Saar Territory is now definitely in being ; at a time when labour troubles, such as the great coal strike, were paralysing the trade of Great Britain, and other countries, too, were in the throes of industrial unrest, the situation in the Saar was perfectly calm. The Saar miners, indeed, were invited by their British colleagues to strike in sympathy, but, after a consultation with the French authorities responsible for the mine administration, they contented themselves with a message of sympathy, and continued work ; much of their coal, in fact, found its way to England in those difficult days. Now, with trouble in the Ruhr, the Saar miners are on strike, and British coal is finding its way to Germany.

Whether in the Saar mines the French have really got a good bargain is, of course, for them to say. The wages of the miners go into Sarrois pockets, and not into French ; the Governing Commission levy their just dues ; so that, by the time the coal is delivered to the factories in France, a good deal of money has been disbursed by France to foreigners instead of to Frenchmen. In the event of the plebiscite going in favour of Germany, it is not difficult to suppose that the French will welcome the German claim to buy back the mines—" Ah ! Take the cash in hand, and waive the rest "—more especially as by that time the French miners in the Pas de Calais will be well on the way towards their pre-war output.

The various steel works in the Saar have suffered, of course, like all industrial concerns, from lack of orders, but no serious stoppages occurred. While both French and German currencies are legal

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tender in the Saar Territory, the result of the payment of the miners in francs and the substitution of French for German currency in the railways and posts and telegraphs must inevitably produce, together with certain other economic tendencies, a general orientation of trade and industry towards France instead of towards Germany. The sudden collapse of the mark, too, has doubtless accentuated this movement. To assume from such changes and developments that political sympathies will follow suit, would be rash indeed. There is, however, plenty of time between now and the date of the plebiscite for a lot to happen ; all that one may predict with reasonable certainty is that a continuation of the wise and beneficent rule of the Governing Commission representing the League of Nations will ensure the content and prosperity of the people of the Saar and justify the conception of this great experiment.

(The article was written in the early part of the year, and since then certain events have occurred to bring the Saar Government before the notice of the British public. The extraordinary ordinances of the Governing Commission, to which attention was recently drawn in the House of Commons, have been withdrawn, and the League of Nations Council has enquired into the whole matter. Reports of the enquiry have appeared in the Press. The strike of the Saar miners is over, and things appear to be now practically more normal.)

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R.E. WORK AT KILIA AND CHANAK.

PART I.

THE work of the Royal Engineers in connection with the Turkish crises will be published in two Parts. Part I contains an account of the work actually carried out at Kilia and Chanak. Part II, which will be published in the December quarterly *R.E. Journal*, will give an account of the preparations made at home in connection with this work, and enumerate the main lessons which are to be drawn from our experience in connection with the preparations for a small war of this nature.

THE FORMATION OF A BASE AT KILIA, DARDANELLES.

September, 1922 *to June*, 1923.

INTRODUCTION.

KILIA Bay lies on the European side of the Dardanelles, opposite Nagara Point, some five miles north of Chanak.

The Imperial War Graves Commission has its headquarters here, together with one English contractor, and these were the only British inhabitants.

On September 23rd, 1922, Major E. U. Grimshaw, M.C., R.E.(M.), was sent from Constantinople to reconnoitre Kilia and the valley running due west to Gaba Tepe, with a view to establishing Lines of Communication and an Advanced Base.

At this time the only buildings in Kilia were the huts—officers', workshops and quarters—occupied by the Imperial War Graves Commission. There was also one good central pier which they had constructed, and there were lightly-metalled roads running west to Gaba Tepe, south to Maidos and thence to Krithia and Seddul Bahr, and north to Azmac and Gallipoli, as well as various tracks used by the natives which led to their villages.

The I.W.G.C. had sunk wells of their own and had sufficient water to supply their colony. In September they erected two tanks at the head of the pier, ready to send water by lighter to supply the troops at Chanak, as the pumping station, which supplied most of the water for that town, was already overlooked by the advance guards of Mustapha Kemal's army.

PERSONNEL.

By the end of September the work of forming an advanced base at Kilia was in hand.

The first Royal Engineers to arrive were a detachment of the 24th Fortress Company, from Malta, about 70 strong and one officer, which landed on the 26th September, 1922.

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The C.R.E., Lieut.-Col. G. C. E. Elliott, C.M.G., D.S.O., arrived on September 30th, together with the O.C. of the 24th Company, Major J. R. W. Mansfield, who brought about thirty more men of his Company.

By the first week in October, there were six R.E. Officers in Kilia, as well as Captain H. G. MacGeorge, who held the position of Assistant Area Commandant, while the C.R.E. also combined with his R.E. duties the task of commanding the Area for about five weeks.

The 29th Army Troops Company, R.E., under Major K. B. Godsell, D.S.O., M.C., moved from Constantinople to Kilia on the 3rd November.

The 15th Fortress Company from Gibraltar, under Captain B. K. Young, M.C., arrived on the 23rd of the same month.

At the end of January, 1923, there were altogether, besides the three companies, each approximately one hundred strong, eighteen R.E. Officers in Kilia, namely, the C.R.E. and an Adjutant, Officers in charge of R.E. Stores (the R.E. Central Stores had moved from Constantinople to Kilia on the 21st December, 1922) and R.E. Stores in Transit, an Officer i/c Roads, an Officer i/c Railways, with an Officer assisting him, an Officer i/c Water Supply, an Officer i/c Machinery and Electric Light, and nine Company Officers.

LABOUR AND CONTRACTORS.

(*a*) *Direct Labour.*—During October a fair quantity of labour was found at Maidos, a village one mile south of Kilia. This village was overflowing with Greek refugees, who had fled there after the Smyrna debacle. At the beginning, about two hundred applicants for work appeared daily, of whom the R.E. got sixty or seventy, some of them being semi-skilled carpenters. The numbers increased gradually as news of this chance of finding work spread to the more distant villages, so that throughout the month labour was comparatively plentiful. In addition to these local resources, consisting almost entirely of Greeks and Armenians, two hundred Russians—ex-members of General Wrangel's White Army—had been collected from Gallipoli village and billeted at Boghali Fort, one mile and a half north of Kilia.

About the second week of November, the Greek evacuation of the Peninsula took place, and the two hundred Russians were the only labour available for all the units in Kilia. In addition, the carpenters, of whom a large gang of fairly skilled workmen had been formed out of these casual labourers, were lost. This was all the more serious as it occurred just as the first ship-load of Nissen huts was being off-loaded.

A labour battalion for unskilled work was then recruited in Constantinople, and started to supply labour early in the following month. The Chief Engineer sent down gangs of carpenters, also recruited in Constantinople. The first batch, consisting of twenty-

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four, was sent down on November 24th, followed by a second party of a hundred and thirty a week later.

These carpenters were retained and increased in numbers up to the end of March, 1923, when the main building works in Kilia had been completed.

The maximum number of civilian labour directly employed by the R.E. was about 250 skilled and 250 unskilled.

(*b*) *Contractors' Labour.*—The chief services carried out by contractors were repair and construction of roads, quarrying of stone and building of the Decauville railway.

Many Nissen huts were put up by petty contracts, made with the foremen of gangs of carpenters already mentioned. The standard price was three pounds sterling for erecting a Nissen hut 30 ft. × 16 ft. and six pounds for a Nissen hut 60 ft. × 20 ft.

The first contract work done was the strengthening of the pier and the repair of certain roads in Kilia. This work was carried out by the I.W.G.C. contractor. A Greek Government contractor from Maidos then offered his services, and carried out a great deal of work up to the time of the Greek evacuation.

Two contractors, who had previously done much work for the British Army in Constantinople, were sent down and employed, one on roads and the other on the Decauville railway, the former for four and the latter for six months.

Water Supply.

(*a*) *Deep-Well Bores.*—Four deep-well bores have been put down. Details are as follows :—

No. 1.—Above Area Headquarters Camp. Depth, 100 ft. Output, 2,000 gallons per hour. 10-h.p. Tangye engine installed driving Duke & Ockenden deep-well pump, which delivers water through 3-in. rising mains, either to I.W.G.C. tanks (increased in number to give 16,000 gallons storage) or to two sail-cloth tanks (capacity, 15,000 gallons) on spur west of bore. Delivery from I.W.G.C. tanks through I.W.G.C. system, with extensions to supply H.Q. camp and water-cart filling point. 4-in. main laid from sail-cloth tanks to supply camps on north side of Gaba Tepe road.

No. 2.—Near 21st Stationary Hospital. Depth, 150 ft. Output, 1,350 gallons per hour. Similar engine and pump to No. 1, delivering through 4-in. rising main to two sail-cloth tanks (15,000 gallons capacity) on hill-side east of bore. Two 4-in. mains laid from tanks, one to supply Hospital, and the other to the R.E. and other camps on north side of Kilia valley.

At the beginning of March, it was found necessary to deepen this bore, as, if more than 500 gallons per hour were taken from it, the quality of sand brought up destroyed the valve leathers. On

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removing the pump, the valves and pump barrel were found very much worn, and no leather cups were left on the plunger. If a 750 or 1,000 gallons per hour pump had been available, the bore could have been used without further deepening. The deepening was commenced on March 14th, and the bore was sunk another 50 ft. to a depth of 200 feet, but much difficulty was caused by the quantity of running sand, and because of having to handle two hundred feet of casing in this class of strata. It was then discovered that the Norton-tube well near the Hospital [mentioned in para. (*c*)] if fitted with a Merryweather pump, would yield 1,320 gallons per hour, and, as success in shutting off the running sand had not been attained, it was decided to abandon the bore and supply the Hospital from this Norton-tube well. The bore had been cased off to a depth of 195 ft. It was found possible to jack out the first hundred feet of casing, but no more. The new 8-in. casing spear was tried, but was a failure, as it would not engage in the casing. A charge of gun-cotton was then made up and put down to a depth of 155 ft. This blew and left in the bore the bottom and a portion of the next lengths of casing.

No. 3.—Near 85th Casualty Clearing Station. Depth, 105 ft. Output, 3,000 gallons per hour. Similar engine and pump to No. 1, but delivery through 4-in. rising main to two sail-cloth tanks (15,000 gallons capacity) on spur west of bore. Delivery from the tanks consisted of (i) 2-in. main to 85 C.C.S., which was afterwards turned into a V.D. hospital for 250 patients ; and

(ii) 4-in. main, 1,400 yards long, delivering to the storage tanks of the Infantry Battalion camps, namely, one 7,500-gallon sail-cloth and two 2,300-gallons canvas tanks (total storage capacity, 10,500 gallons). As well as feeding the two Infantry Battalions, this feeds the Ammunition Dump.

No. 4.—Near Royal Fusiliers Transport Lines. Depth, 215 ft Output, 500 gallons per hour. 4-h.p. Lister, driving Duke & Ockenden 1,000-g.p.h. pump, installed. A most unsatisfactory bore, which met with difficulties all the way down and still does not pump satisfactorily. Delivery through 4-in. rising main to two sail-cloth tanks (10,000 gallons capacity) on spur south-east of bore. Delivery from tanks by 4-in. main to Ordnance Depôt and camp, with a direct 4-in. main to a central fire hydrant.

(*b*) *Shallow Wells.*—Fifteen of these have been dug—average depth 15 ft. These are used chiefly for the supply of washing water, the water not being fit for drinking purposes without treatment.

At the Infantry camps a sterilizing plant was installed. This draws water from two shallow wells, and, after sterilization, delivers it into a tank from which it is pumped by a No. 2 Merryweather steam pump to two 2,300-gallon canvas tanks erected at the highest point of the camp. Distribution from these tanks is by 2-in. pipes. As the yield of these wells was hardly sufficient, an attempt was made

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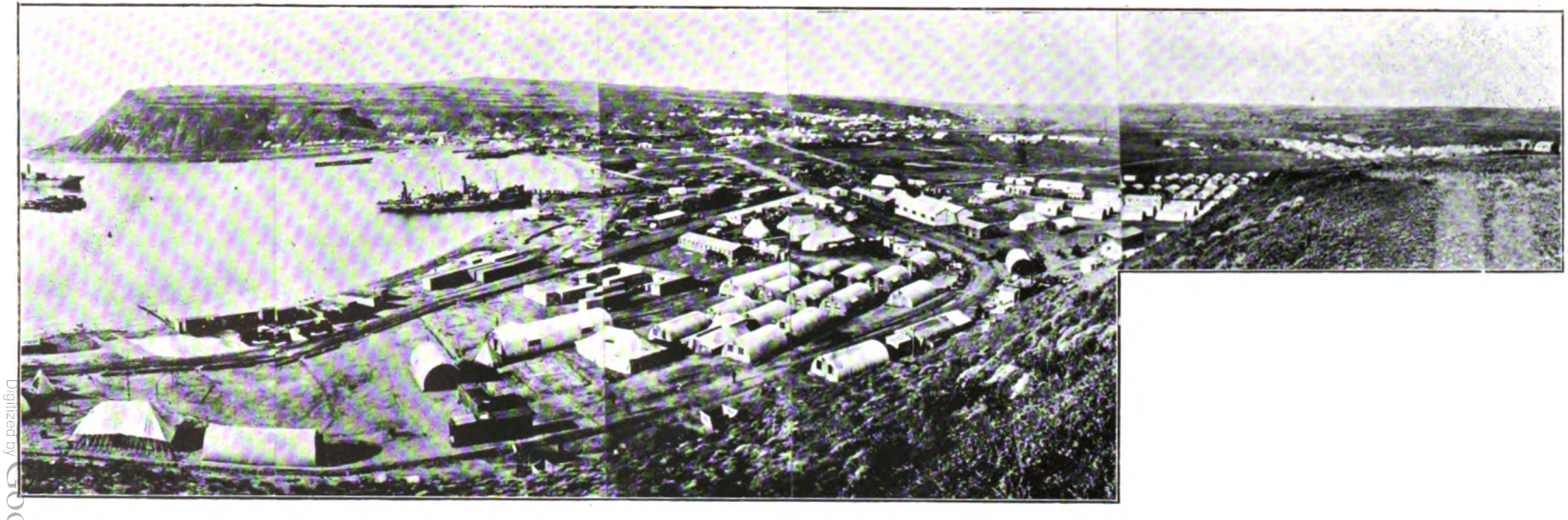
R.E. WORK AT KILIA AND CHANAK.



The Base at Kilia—Dardanelles.

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to improve it as follows :—6-in. perforated casing was driven to a depth of 24 ft. below the level of the bottom of one well, and cleared with a boring tool and bailer, worked by means of a derrick and winch. This increased the yield of the well by 100 per cent., and the same thing was done with the second well, but the result was not quite so good, giving only about 60 per cent. improvement.

Six other shallow wells were also dug in the Gaba Tepe area and lined with rolled galvanized iron sheets—diameter 1·8 metres, depths from 6 to 11 metres. One only at Gaba Tepe has been used. This was 9·3 metres deep. A Chaîne-Hélice pump was fitted, and 200 gallons per hour obtained without exhausting the well.

(*c*) *Norton-Tube Wells.*—A few of these have been tried, but only one was successful for bulk supply. This was at the Hospital and has already been mentioned. Here a 2-in. tube was put down to a depth of 24 ft. In another case a good supply was obtained, but the water was heavily charged with sulphuretted hydrogen and could not be used.

(*d*) Supplies have been laid on to the Ordnance and 86th Field Ambulance camps by tapping aqueducts which formerly supplied Turkish fountains, and piping the water to tanks in the camps. In both cases the overflow from the tanks supplies horse troughs.

(*e*) At various outlying camps (battery positions, etc.) tanks have been fixed and short pipe lines laid, through which water can be pumped to camps by lift and force pumps from shallow wells or springs in the vicinity. A Merryweather steam pump has been installed at Kilid Bahr aerodrome.

Captain A. W. S. Gibson was Officer in charge of Water Supply, and he had Mr. Palmer, ex-Staff-Serjt., R.E., in charge of the deep boring plant.

Hutting.

During October the troops were all under canvas, and corrugated-iron cook-houses and latrines only were built. At the beginning of November five office huts were built for Area Headquarters, the Headquarters Heavy Artillery and the C.R.E. These were made about 28 ft. by 14 ft., of corrugated iron and timber, with an ordinary "A" roof. The office of the I.W.G.C. contractor, which had been generously lent to provide accommodation for the Area Commandant, was handed back.

The first Nissen huts—old pattern and nominally reconditioned—arrived from Constantinople on the 10th November, but the absence of bolts, which had been mislaid in the confusion then existing on the beaches, delayed the work of erection for about ten days. The first Nissen hut was completed at the 21st Stationary Hospital on the 22nd of November.

The scheme was to give each camp one or two Nissens, in which the

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occupants of any tent which was wrecked by bad weather could find temporary shelter.

The first consignment of the 1922 pattern Nissen huts arrived from England towards the end of November, consisting of 125 30 ft. and 25 60-ft. huts. Even then the task of hutting proceeded somewhat slowly, as, owing to the hasty packing in the ship, no complete Nissens could be got on shore till practically the whole cargo had been off-loaded. By the end of the year, however, there were sufficient huts erected for all the troops to be able to find somewhat crowded accommodation in case of need.

Altogether 150 large, 700 small 1922-pattern and 365 reconditioned old-pattern Nissen huts arrived from England by the middle of December, as well as about 250 small old-pattern Nissen huts from Constantinople. Over 900 Nissen huts in all have been erected on the Peninsula.

Except in the case of the Infantry Battalions, who erected their own huts under R.E. supervision, the majority of the huts were erected by native carpenters. A gang of ten men could erect a small Nissen hut in one working day and a large Nissen hut in two and a half days.

In addition to Nissen huts, there may be now also seen in Kilia "A" sheds, Malta huts, ruberoid huts, universal shedding, and corrugated-iron buildings of every shape and size—offices, workshops, signal boxes, engine sheds, garages, operating theatres and even a guinea-pig hutch for the pets of the Hospital biologist.

ROADS.

The first piece of road work taken in hand was the making of the road, 4 metres wide and 201 metres in length, which ran alongside what was then the R.A.S.C. Supply Depôt (now Broadway), which was undertaken by the firm of Sir J. F. Payne Gallwey, Ltd., early in October. This was followed by the joining up of the eastern end of this road with the Central Pier, a distance of 80 metres, at 4 metres width, carried out by a Greek contractor, M. Guirdjis.

Meanwhile, minor road repairs were being carried out, chiefly on the Gaba Tepe road, by direct labour. Stone was supplied by contract, unbroken, and stacked alongside the road. A women's gang of about a hundred members was formed from the inhabitants of Maidos, and was employed in breaking this stone. About six to seven hundred metres of stone were used in this way.

M. Guirdjis carried out the following road work up to the middle of November, when he departed for Greece at the time of the Greek evacuation of the Peninsula :—

(*a*) Re-making the road 4 metres wide from the Ordnance Depôt towards the Kilia aerodrome, for a distance of approximately 3 kilometres.

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(*b*) Construction of a 4-m. road, from Pontoon Pier to the Coast road, now called Brompton Road, a distance of 77 metres.
(*c*) Widening the road alongside R.A.S.C. Depôt, previously mentioned, to a width of 8 metres.

Other road work done by contract (name of contractor shown in brackets) has been as follows :—

(1) Road through Ordnance Depôt, 6 metres wide by 240 metres in length (M. Papaleo).
(2) Road past R.E. Dump, 7 metres by 133 metres (Payne Gallwey).
(3) Widening of Brompton Road (Payne Gallwey).
(4) Road in front of Ordnance, 5 metres by 263 metres (Papaleo).
(5) Road to Hospital, 5 metres by 295 metres (Kimbulian)
(6) Road through Hospital towards 86th Field Ambulance, 3 metres by 102 metres (Kimbulian).
(7) Road to Maidos, 7 metres by 315 metres (Payne Gallwey).
(8) Road from Maidos-Cham Burnu road to Kilid Bahr aerodrome, 4 metres by 4,000 metres, of which about 400 metres are beech-plank (Farfan).
(9) Road from Area Headquarters towards Ordnance, 5 metres by 600 metres.

Total length of road made or re-made by contract, 9,500 metres lineal.

In addition to these road repairs and constructional works, there has always been a gang of labour employed under direct R.E. supervision. This gang averaged 200 from January to March, 1923.

Two quarries were opened up and worked by contract, the stone supplied being used by the maintenance gang. In addition, about 600 tons of stone were sent down from Constantinople.

Roads to the north of Kilia as far as Azmac and south to Seddul Bahr were kept open through the winter by R.G.A. working parties, the stone used being collected in the neighbourhood.

A beech-plank road was made by a Royal Fusiliers working party from the Hospital Road to Brompton Road, and was continued along in front of the R.E. Dump.

When the weather conditions improved, the maintenance gang was cut down to about twenty, who were used for repairing "pot-holes," and since April the roads have been kept in very fair condition by this gang. Horse transport becoming more plentiful, stone, both broken and unbroken, was collected from the neighbourhood of Yalova and used in repairing the roads in Kilia.

From December, 1922, Major F. A. Ferguson, D.S.O., was in charge of Roads.

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KILIA LIGHT RAILWAY.

Early in October it was decided to lay a 60-cm. Decauville line at Kilia, to relieve the congestion on the roads by connecting up the various dumps and piers.

Technical Details.—60-cm. line, to be built of such rail as was available locally or in Constantinople, namely, 12½ lb., 19¼ lb. and 19½ lb. per yard.

Ruling grade 1/50, except at Gaba Tepe end, where a steeper grade of 1/40 was proposed.

Ballast—20 cm. deep, 2 metres wide, on a formation of 3 metres. Gravel, sand or broken stone being used as available. Stone was of poor quality and very soft.

Bridges to take 14 tons.

General Details.—Work was commenced on the line at Kilia from Central Pier to Ordnance on October 18th, by a contractor who was brought down from Constantinople, with 130 men.

The material immediately available was a miscellaneous assortment of rails from Gallipoli, containing rails of three different sections, a small number of fish-plates, and no new bolts. A few parts of points and crossings were also found locally.

By November 26th, 3,667 metres of line had been laid and ballasted, but the bolting-up was only provisional, as proper fish-plates and bolts were not yet available. The line was worked by mule transport up to November 27th, when an engine became available. From November 19th to December 2nd, owing to labour difficulties arising out of the Greek exodus, the contractor was able to provide only ten men per day. This difficulty was overcome by getting as many men as possible from the recently-formed labour corps—varying from 30 to 90. Their work was indifferent and much slower than that done by the contractor's men.

On November, 25th, two German six-wheeled coupled engines and 15 five-ton bogies arrived. They had to be completely dismantled, as they were in very bad order, but by working night and day, Mec.-Q.M.S. Parslow, R.E., managed to get one running by 28th November, and the pair by November 30th—a very excellent piece of work.

On December 14th, two engines, four-wheeled coupled, arrived from Malta. They were in good order and were put into the service right away. Later four 40-h.p. petrol Simplex tractors and two 20-h.p. tractors arrived. They required a lot of adjustment before they would work satisfactorily.

By the middle of February, 9,000 metres of line had been laid, linking up the three piers, providing three lines in the Supply Dump, one in the Ordnance Depôt, two loops in the Infantry camps, and lines to the Stationary Hospital and C.C.S., and loops and sidings to the R.E. dumps and to sand-pits.

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Personnel.—The whole of the railway work has been done under the supervision of Major E. U. Grimshaw, M.C.

On December 9th, Lieut. S. Lamplugh joined the Railway staff as traffic manager.

Up to November 22nd, all work, including maintenance, was carried out by six British O.R.'s and a contractor employing from 130 to 300 men. On November 23rd, Mec.-Q.M.S. Parslow arrived, together with 38 railway personnel from the Anatolian Railway, with a good superintendent. This party was increased on December 2nd, by 20 more men. From this date all normal maintenance was carried out by the Railway staff. The upkeep of the line has entailed continuous and extensive work, owing to the bad weather, the lightness of some sections of the line, the softness of the ground and the difficulty of getting sufficient sand and stone for ballasting the line.

Cost.—The actual cost of laying the line, including first lift, has been approximately 14s. per metre run.

Tonnage.—The normal tonnage handled per day averaged 450 tons, which rose occasionally to 600 tons.

Speed of Work.—At first work was slow, owing to lack of material and insufficient labour, but this gradually corrected itself. A large amount of improvisation had to be carried out, especially on points and crossings. An improvised plate roller for corrugated-iron culverts up to 4-in. diameter has effected a great saving, both in time and expenditure, on small bridges.

Total Length of Line.—The extension of the line as far as Gaba Tepe has been surveyed, and makes with the length of *main* line already completed a distance of 8¼ kilometres.

Electric Light and Machinery.

The first electric light plant to arrive was a Siemen-Schukert 110-kw. portable engine. This at first supplied light to the Hospital.

Four electric light stations in all have been fitted up in Kilia :—

(1) At the Hospital, consisting of two Halford 18-kw. sets, run in parallel. These supply about five hundred points in the 21st Stationary Hospital, 86th Field Ambulance, the "S" Coast Battery camp, the N.A.A.F.I. compound, and also the Cinema and Concert Hall.

(2) At Area Headquarters, consisting of a portable Ruston-Proctor steam-engine driving a dynamo, with a Halford set similar to those at the Hospital, as a stand-by in case of breakdown. This lights the Base Supply Depôt, Area Headquarters camp, the I.W. G. C. Compound and the Central Pier.

(3) A Siemens-Schukert, lighting the R.E. camps, the Pontoon Pier and the Seaplane Base.

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(4) A 50-h.p. Petter set, at Ordnance, run by Ordnance workshops, lighting No. 9 M.T. Company, the Ordnance Depôt and camp, and the Infantry camps.

In addition to the above electric light stations, there are three or four small sets, such as Petter Juniors, in use at the out-stations.

There are also four deep-well pumps and several Merryweather pumping sets in use, and four saw-benches.

The whole of the machinery and electric light work has been carried out under the supervision of Lieut. L. Delanoy, R.E.

R.E. STORES.

The first consignment of R.E. Stores, consisting of corrugated iron, timber, nails and tools, was received from Constantinople on the 25th September, 1922, and, after being discharged at the only existing pier, was dumped on the site of the present R.E. Stores. This was followed by several more consignments sent down from Constantinople on small boats, arriving about twice a week. The facilities for unloading stores at Kilia were meagre, and there was congestion at the Pier head, where R.E. Stores were mixed up with stores belonging to the R.A.S.C. and the Ordnance. The only means of collecting them into the Dump was by country carts, and there were not sufficient of these to meet demands. The Stores Staff had not yet arrived, and the 24th Company being the only one here and busily employed on works, could not spare sufficient personnel for checking the stores.

During October the claims from Chanak for stores received priority, so that there was an insufficiency of corrugated iron and timber for the works in Kilia. The situation as regards timber was greatly assisted by the requisitioning of some 300 cubic metres in Maidos, but corrugated iron remained a difficulty until the *Lamington* arrived at Constantinople with supplies from England.

The first consignment of stores from England which was off-loaded direct at Kilia, arrived in the *Esperia* in the middle of November. This ship brought, besides 150 Nissen huts, 170 tons of corrugated iron, 162 tons of timber, about 500 tons of stoves and cooking-ranges, the star-drill and 4 deep-well pumps and engines.

Before the off-loading was completed, the *Crosshill* arrived at the beginning of December, with 700 Nissen huts, 80 tons of corrugated iron sheets, 60 sections Martell Girders, more stoves and cooking-ranges, 4 saw-benches, with engines and 1 petrol tractor for the Decauville railway.

This was followed by the *Hillhouse*, which reached Kilia in the

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second week of December with 285 Nissen huts, 300 tons Universal shedding, 250 tons of "A" type shedding, 150 tons of stoves, 3,000 sheets of SX boarding, 5 petrol tractors and 10 bogie trucks.

Besides these big consignments of stores received direct from England, smaller boats were still coming down about twice a week with stores from Constantinople—some obtained locally, some from R.E. Stores and some from the *Lamington*, the stores from which were being unloaded and sorted in Constantinople.

During October, November and the first half of December, there was a considerable congestion all along the beach. The Shipping Department with their lighters were able to put 800 tons a day on shore; but it was quite impossible to keep up with this rate in clearing the beaches.

A check of the R.E. Stores landed was impossible, as items urgently required were collected direct from the beach and put into immediate use, without going through the hands of the Stores Staff at all. The stores were not marked to show which boat they were supposed to be carried by, which increased the difficulties of completing a check after the situation had been eased.

In addition, stores coming down from Constantinople, although consigned definitely either to Chanak or Kilia, were indiscriminately landed at either and, though every effort was made to square matters between the forces on either side of the Straits, it was impossible to find all the stores shown on any particular voucher.

The Stores Staff in Kilia consisted of 1 W.O. in charge and 2 Engineer ledger-keepers and Storemen up to the time when the R.E. Central Stores moved from Constantinople to Kilia, which took place on the 21st December, 1922.

About the same time an Officer was put in charge of a small staff with a gang of native labourers, whose duty it was to collect and stack the R.E. Stores which were being landed, and also to issue Nissen huts direct from the dumps on or near the beach.

Nissen hut dumps were formed just clear of the beach in three or four places along the shore, and a second main Dump was formed east of the road running from South Pier to what is now called Hyde Park Corner—the meeting place of the Gaba Tepe and Yalova roads.

After the main rush was over, namely, from the middle of January, the beaches were cleared of R.E. Stores, and only the two main Dumps maintained.

At the present time issues both to Constantinople and Chanak are made from the R.E. Stores at Kilia.

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THE OUT-STATIONS.

(1) *R.G.A. Camps.*—Prior to the arrival of the R.G.A. on the Peninsula there were two 4-in. Naval guns at Akbash, under a Naval officer, which had taken up their position on September 25th, 1922.

The 1st Heavy Brigade, approximately 650 strong, landed at Kilia on the 10th October and camped for nearly a fortnight on the ground now occupied by the " S " Coast Battery Camp and the 15th and 29th Companies, R.E. On the same day, three Naval batteries, 220 men in all, took up their positions on the Peninsula ; one at Seddul Bahr, one at Soghanli and the third at Kilid Bahr. They were all accommodated under canvas, corrugated iron cook-houses of a temporary nature being hastily constructed.

Between the 19th and 29th October, the four batteries of the 1st Heavy Brigade moved out to their permanent camp sites at Azmac, Akbash, Soghanli and Seddul Bahr, and the brigade camp was taken over by the 5th Medium Brigade, 620 strong. The weather had not yet broken, so that, by making detours, the caterpillars of the Heavy Brigade with their loads were able to avoid most of the road bridges, and, with the help of some heavy timber baulks, climbed in and out of the dry river beds.

During November, battery camps were formed for the 5th Medium Brigade at Boghali and Jambaz and at the end of January, 1923, yet another camp was formed at Cham Burnu. The R.A. Survey Company arrived on the Peninsula at the beginning of December and went into camp at Yalova.

The same principle was observed in the hutting of these out-station camps as in the camps in the Kilia valley, namely, one or two huts were erected in each camp to be used as a protection against bad weather in case of emergency. These batteries were, however, much better able to fend for themselves, as old stone huts, in various stages of decay, existed in most of the camp sites. These, built up, with corrugated iron roofs added, were first used for accommodation. Water was found in existing shallow wells, which were improved and fitted with lift and force pumps, Nissen huts were allotted in bulk, and the detailed distribution was done by H.Q., H.A. In all, 190 Nissen huts have been erected at these R.G.A. camps.

At first the Peninsula, south of an east-and-west line drawn through Maidos, came under the C.R.E., 28th Division, but in the middle of January, 1923, the C.R.E., Kilia, took over the whole Peninsula.

The roads running north and south from Kilia were all lightly metalled. A good deal of work was put in by the Gunners themselves,

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in keeping these roads open through the winter, but no extensive reconstruction work was undertaken. The batteries were fed in the latter part of the winter by sea transport, and the roads, for a time, became nearly impassable to traffic.

(2) *R.A.F. Aerodrome at Kilid Bahr.*—It was found when the weather broke that the old aerodrome ground west of Kilia became too sodden for the landing and taking-off of aeroplanes. At first it was decided to experiment with canvas and wire netting laid down as a landing surface, but this was not proceeded with, and a new site was chosen on the Kilid Bahr plateau at a height above sea-level of about 200 metres. This site was very suitable, both as regards landing facilities and through being out of sight from the Asiatic shore, but the great difficulty was road communication with Kilia. The work of constructing a road, to join the main road south of Maidos, was commenced by contract at the beginning of December, and the line of an old country track was followed. The total length of the road to be made was 4,030 yards, from sea-level to the height of the aerodrome. Local stone was used, though of poor quality and very soft. The road had to be used by traffic the whole time it was being built, as the personnel of No. 4 Squadron was already on the plateau and had to be rationed. In addition, a hutted camp was being built at the same time, so that Nissen huts and other material had to be taken up. The road was finally completed and taken over at the end of March, 1923.

(3) *Wireless Stations, Anzac.*—At the end of September, 1922, it was decided to move the Wireless Station from Nightingale Hospital, Chanak, to Anzac, where it would be in a safer position in case of war. The technical buildings were put up by contract, and the station started to function in the middle of October. It was capable of communicating direct with England or Egypt. Living accommodation for the personnel was provided at the same time as in other camps. A listening-in station for Intelligence purposes was also constructed at Shell Green, about two miles south of Anzac, at the beginning of February, 1923.

Special Works.

The following constructions are worthy of being mentioned separately as being somewhat out of the ordinary.

Towards the end of September, H.M. Aircraft Carrier *Argus* landed about a dozen seaplanes at Kilia, and it was necessary to supply a slipway up which they could be hauled on to land without undue strain.

The slipway was made of timber, cased at the seaward end round blocks of concrete, and a concrete platform, about the

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size of a tennis court, was built on which the seaplanes were parked.

At the beginning of January it was decided to build a cinema and church for the use of the troops. As this building is fully described under Professional Notes (page 499) no further mention need be made of it here

Engine sheds for Decauville engines were built by raising the curved corrugated-iron sheets of a small Nissen on iron pickets about 6-ft. high.

A signal box was constructed, with its floor 10-ft. above the ground, over the manager's office, and was appropriately named Clapham Junction.

PIERS.

Two new piers were constructed. One, at the northern end of the Bay, near the R.E. Dump, consisted of an iron pontoon anchored in position after much difficulty, and connected to the shore by a roadway supported on a trestle, both road-bearers and trestle consisting of 12 in. × 12 in. timber baulks. This was in use by the 8th of November and proved invaluable, though it gave trouble subsequently on two or three occasions owing to the rough weather. The size of the pontoon was 200 ft. × 40 ft. × 12 ft. high, and was the spare pontoon for the main floating bridge across the Golden Horn.

A concrete pier, at the southern end, was started by contract on the 27th November. The supply of cement became short, and it was temporarily abandoned in an unfinished state. It was eventually completed in January, by the 29th Company, R.E.—a concrete pier-head was made and this was joined to the unfinished portion of the pier by girders and a timber roadway.

DIFFICULTIES.

(1) *Lack of Transport.*—The temporary set-back caused by the sudden departure of most of the available native labour has already been mentioned.

In addition to this, there has been the almost constant difficulty of finding sufficient transport. None of the R.E. Companies had any transport of their own, and all have been entirely dependent on the transport pooled under the L.T.O.

At the beginning there was an insufficiency of all forms of transport, but by December, enough horse transport had been collected for everyone to get as much as demanded. Motor transport has always been a difficulty. The only motor transport permanently

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available has been 3-ton lorries, which, owing to the uncertain state of the roads, were almost useless during the greater part of the winter.

The Heavy and Medium Brigades of Artillery brought with them 30-cwt. Vulcan and 15-cwt. Crossley lorries, and about six of each of these were added to the L.T.O.'s pool for general use. There have always been so many applicants for these very useful vehicles, that it was never possible to be sure of obtaining them when required. The planning of work would have been greatly facilitated if each O.C. R.E. Company had definitely had a certain amount of transport permanently under his own orders.

(2) *Unloading of Stores.*—Stores began to arrive in great quantities at a time before the Decauville railway had started to operate, and when the supply of road transport was at its ebb. The shipping department had facilities for landing two or three times as many stores in a day as could be cleared from the beach, so that, of necessity, the beach became more and more congested.

By the middle of November, Ordnance, R.A.F., R.A.S.C. and R.E. stores were in large stacks along the shore, and in a state of considerable confusion. A great effort was then made, and, with the help of the Decauville railway, which, by the end of the month, was removing 500 tons of stores from the beach daily, the tangle was gradually straightened out and the stores position mastered.

(3) *Weather.*—The weather through the winter was comparatively mild, except for two or three blizzards. However, there was plenty of rain and mud and, for a time, it was touch and go whether the roads could be kept open: in particular, the main Gaba Tepe road, leading past Area Headquarters and the Supply Depôt, to the Ordnance Depôt and the Infantry Battalion camps.

This for a short time became impassable for motor traffic, but was always used by horse transport. The difficulty was finally overcome by laying rough *pavé*, similar to that found in French provincial towns. In Constantinople this is termed *pavé ordinaire* as distinct from *pavé cubé.*

R.E. WORK AT CHANAK.

September, 1923—June, 1923

(1) *Personnel and Organization.*—During the summer of 1922 the British Army was represented at Chanak by a single Battalion of Infantry, and the R.E. by one section of a Field Company, the

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Section Officer acting as D.O.R.E. The Battalion was billeted in the town, for the most part in buildings belonging to the Turkish Government and previously used as barracks, hospitals, and store-houses. The chief work which fell to the R.E., beyond minor repairs to billets, roads, and the rifle-range, was the maintenance of the water supply, of which an account is given in para. 3.

In September, Chanak leapt into importance on the approach of the Turkish Army. Reinforcements of all arms were sent from Constantinople, Egypt, Malta, Gibraltar and the United Kingdom, and another section of the 55th Field Company was at once sent down from Haidar Pasha. These two sections had to carry on through the most strenuous period of preparations for defence until October 2nd., when the 12th Field Company arrived from England. They then returned to rejoin their own Company. On October 1st, a Division Head Quarters was formed at Chanak, and the C.R.E., Anatolia, took up duty as its C.R.E. His staff consisted of an Adjutant, one Engineer-Clerk Staff-Serjeant, and, later, a Q.M.S.-Mechanist Electrician. In addition he had attached to him two N.C.O.'s on loan from other Companies, one of whom was in charge of the pumping-station, and one acting M.F.W. The 12th Company was approximately at peace strength, and averaged 5 officers and 130 other ranks. For a force of an average ration strength of approximately 6,500 this was naturally weak, and it was difficult to withdraw men for rest or training. Out of this number, too, a full section had to be kept until the end of the year on the Gallipoli Peninsula, which came under the Division for all the area south of an east and west line through Maidos.

(2) *Defences and Field Works.*—In September a defensive line was built in great haste to cover Chanak, and as the garrison increased portions of the line were advanced in order to gain a little depth for the defence. In the first instance the line consisted of strong points, which were first completely wired in, then dug, tactical wire and lateral communications being added. Support and Reserve lines were also prepared with splinter proofs for Battalion Headquarters and Aid Posts in the Reserve positions. Front line wiring was done by Naval and Marine landing parties, 1,200 strong, who then dug the strong points, support lines and lateral communications to front line strong points. The 1st Battalion, the Loyal Regiment, dug their own frontage. About 250 native labour were also employed on digging. Battalions as they arrived took over their own frontage, thickened up wire and dug Reserve line. The two R.E. officers then at Chanak were fully employed in siting and laying out these trenches, superintending their construction and arranging the issue of the large quantities of tools and stores required. Several small farms were blown up to clear the field of fire, and, as the Turks

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approached, a road-bridge and a road-mine were blown on the Chanak–Erenkeui road. The batteries dug their own positions and splinter-proof shelters. The defences were of the most simple kind, fire-trenches and apron-fences, and before such improvements as communication-trenches or dug-outs could be put in hand, the Mudania Armistice was signed, on October 11th, under the terms of which no further defensive works were allowed to be constructed.

(3) *Water Supply.*—Chanak is supplied with water from two external sources. The main supply, and much the more important, is from a pumping station on the Koja Chai, about a mile and a half from its mouth. The water, from a well sunk beside the river bank, is pumped by a steam pump to a filter-bed and reservoir 700 yards away on the lower slopes of a hill. From here the town is fed by gravity, but the head is not sufficient to reach the north end of Chanak, where the houses rise in tiers up the hill-side to the building known as Nightingale Hospital on the summit. A small booster pumping-station had accordingly been built by the Army at the bottom of the hill. Its storage capacity was 4,000 gallons, and a Merryweather Valiant pump lifted the water to further storage tanks in Nightingale Hospital.

The secondary and older supply is provided by a pipe fed by a spring in the mountains some two and a half miles south of Chanak. The two systems are interconnected, but this secondary supply has no effect except in the extreme south end of the town, where the piping is very old, rotten, and laid in inextricable mazes. For military purposes this latter pipe is almost useless.

In the event of war, both these sources would have been lost to us. The second pipe could be cut at any point outside our line. The Koja Chai pumping station was only just outside our line, but, even if it had been found feasible to deny it to the enemy, it could only have been a matter of hours before it was shelled to pieces.

Consequently, among the earliest work for the R.E. was the reconnaissance and development of all other potential water-points. There are many shallow wells in Chanak, but all polluted to a varying extent. Inside our wire, but outside the town, a certain number of wells were found of good capacity and yield and of reasonable purity. In addition, the line of hills which connects Chanak with Mal Tepe was found to carry a large quantity of water, issuing in springs at various points, some of which appeared to be connected underground. A reserve up to 12,000 gallons was installed by canvas tanks and filled by water lighter from wells at Kilia.

Until May the bulk of the troops were billeted in Chanak and used the piped supply, and these subsidiary sources were not much drawn on. But, when in May all units were moved from Chanak

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into camps to the north and north-east, three additional pumping stations had to be built, each with its own rising main, reservoir, and distributing system. (J.3,733. J.1,435, and J. 0632). Merryweather Valiant pumps were installed at each of these. In addition, the storage at the booster pumping station (*see* para. 3, sub-para. 1) had to be much increased, and the gravity main feeding it repaired to increase the supply obtained in twenty-four hours.

Norton-Tube wells were also sunk with varying results for two or three small units.

(4) *Billets, Hutting and Camps.*—When reinforcements arrived at Chanak in September and October the tentage available was quite inadequate and hutting was out of the question. On this account, as well as on tactical grounds, practically all units were billeted in Chanak. Most of the billets were very bad; ruinous, dirty, and infested with bugs; but there was no choice. That portion of each battalion which was occupying the line lived partly in tents and partly in crude dug-outs and shelters. Large orders for Nissen huts had been placed in England, but these did not arrive till well into November, and a certain number of reconditioned Nissens were sent down from Constantinople. But it was decided that, with minor exceptions, the troops at Chanak should be accommodated in billets and tents, and that the Nissens should be reserved for the European side. This decision was slightly modified when the winter blizzards began, and 20 Nissens were finally erected at Chanak. In the Divisional Area on Gallipoli 115 were erected for the Medium, Heavy, and Naval Batteries between Sedd el Bahr and Cham Burnu.

When, in May, units moved into camp, a certain number of accessory buildings, cook-houses, forges, etc., were provided, and sun-shelters for recreational purposes.

(5) *Decauville and Roads.*—No new Decauville lines were laid. A small Decauville system in use in the Supply Depôt, and connecting it with South Pier, was maintained. A scheme to connect Chanak with Nagara was worked out, but given up as too slow and costly.

The only lateral communication possible for winter use was the Chanak-Nagara road, which followed the sea-shore and was largely protected from view and shell-fire. Its condition was bad, and it was so important that it was entirely remetalled from Medjidieh Fort to Nagara, a distance of over two miles. The *pavé* road through the town was always possible, though rough. Road communications from front to rear consisted of a single lightly metalled road from Chanak to Karaja Veiran. One Infantry Brigade constructed a road from Mal Tepe to Saral Tepe, but, in spite of the large amount of work put into it, it was not an unqualified success.

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A good deal of work was done on the European side on the main Maidos-Cham Burnu-Soghanli Dere road. It consisted of digging and cleaning ditches, removing mud and repairing bridges, and no new metalling was attempted. Most of this work was done by the R.G.A.

(6) *Machinery and Electric Light.*—Machinery at Chanak consisted, in September, of :—

(*a*) At Koja Dere pumping station, a steam pump lifting 100,000 gallons a day, and boiler, both belonging to the Turkish Government, but run by the British Army. The pump was in good condition and gave no trouble, but the boiler was a source of constant anxiety, and twice caused a stoppage of some days. On the first occasion it was repaired by the Royal Navy (H.M.S. *Centaur*), and on the second by the R.E. As soon as the cross-country tracks became dry enough, a Rushton-Proctor portable engine was moved out as a stand-by.

(*b*) At the booster pumping-station, a Merryweather Valiant. There were added later :—

(*c*) A saw-bench, run at first by the Rushton-Proctor set and, when that was moved out to the Koja Chai pumping station, by a Blackstone 11-h.p. horizontal oil-engine.

(*d*) Three other Merryweather Valiants. *See* para. 3, sub-para. 5.

Electric lighting in September was *nil.* The following were installed :—

(*a*) At Division Headquarters, Turkish 3-O.K.W. 60-volt portable search-light set, mounted on a limber, feeding 97 points.

(*b*) At Garrison Institute—Lister 3-K.W. 110-volt set, feeding 39 points. This set was no longer required in May, and was dismantled.

A workshop lorry was also used with temporary wiring to provide light for boxing competitions.

(7) *Piers.*—There were originally six piers at Chanak, Nagara Fort Pier, Nagara Pier, Aeroplane Pier, North Pier, General's Pier, and South Pier, and of these only three, Nagara, Aeroplane and South Piers, were built out into water sufficiently deep for anything more than a launch or shallow-draught lighter to come alongside. They were all in poor condition, and, in addition to repairs to superstructure, new piles had to be driven at Nagara Fort, Nagara, Aeroplane, and South Piers. Another pier was built under cover of Medjidieh Fort in case of hostilities, consisting of 107 feet of trestle and pile completed by a lighter 146 ft. long, moored at the end ; but even so its head was only in 5 ft. 6 in. of water.

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A small pier was also built near Jambaz Dere on the European side. It was constructed of masonry for the first 40 feet from the water's edge, and of piling for the last 15 feet. The roadway was 11 ft. wide, and there was an average depth of 4 ft. 6 in. at the end.

(8) *Transport.*—The Field Company brought with it 1 G.S. wagon and 4 L.G.S., in addition to its tool-carts, water-cart, and mess-cart, and no other transport was permanently allotted to the R.E., except 1 pontoon wagon and 1 G.S. wagon to R.E. Park. Other transport was demanded from the R.A.S.C. as required, and was on the whole adequate, except under any unusual pressure of road work. Sea transport was used between South Pier and Nagara, and between Kilia and various points on the European shore.

(9) *Direct Labour.*—This consisted of two classes :—

(*a*) Civilian subordinates directly employed and paid from the Works' Vote. They included the tradesmen in R.E. Park, carpenters, blacksmiths, fitters, and engine-drivers, averaging 15 in all. The Greeks originally employed were in November frightened by the Turks into wholesale desertion, and their places were taken by Russians, many of them ex-officers of Denikin and Wrangel. Their trade standard was not high, but they were well-behaved, worked hard, and were very satisfactory.

(*b*) Unskilled labour, obtained day by day on indent from the Labour battalion. Though not paid by the R.E., their cost was charged against the Works' Vote. The number employed daily varied from 5 to 50. They were poor workers.

(10) *Contractor's Labour.*—No labour contractor was employed, but a certain amount of work was carried out by contract. The biggest service carried out by contract was the re-metalling of the Nagara road (*see* para. 5), which was done satisfactorily by a contractor from Constantinople. The same contractor carried out the erection of a certain number of Nissen huts on Gallipoli. The only difficulties that arose over his employment were incidents between the Turkish Police and his employees—Armenians.

(11) *R.E. Stores.*—In October and November, R.E. Stores for Kilia and Chanak were all supplied by sea from Constantinople. It was not possible to obtain separate boats from the two places, loading and unloading were always hurried, and it was a matter more of luck than invoicing where the stores were finally landed. Once they were on the shore, Kilia and Chanak used to try to sort out their respective consignments. Soghanli and Sedd el Bahr were supplied mainly from Chanak, entailing two journeys by sea instead of one

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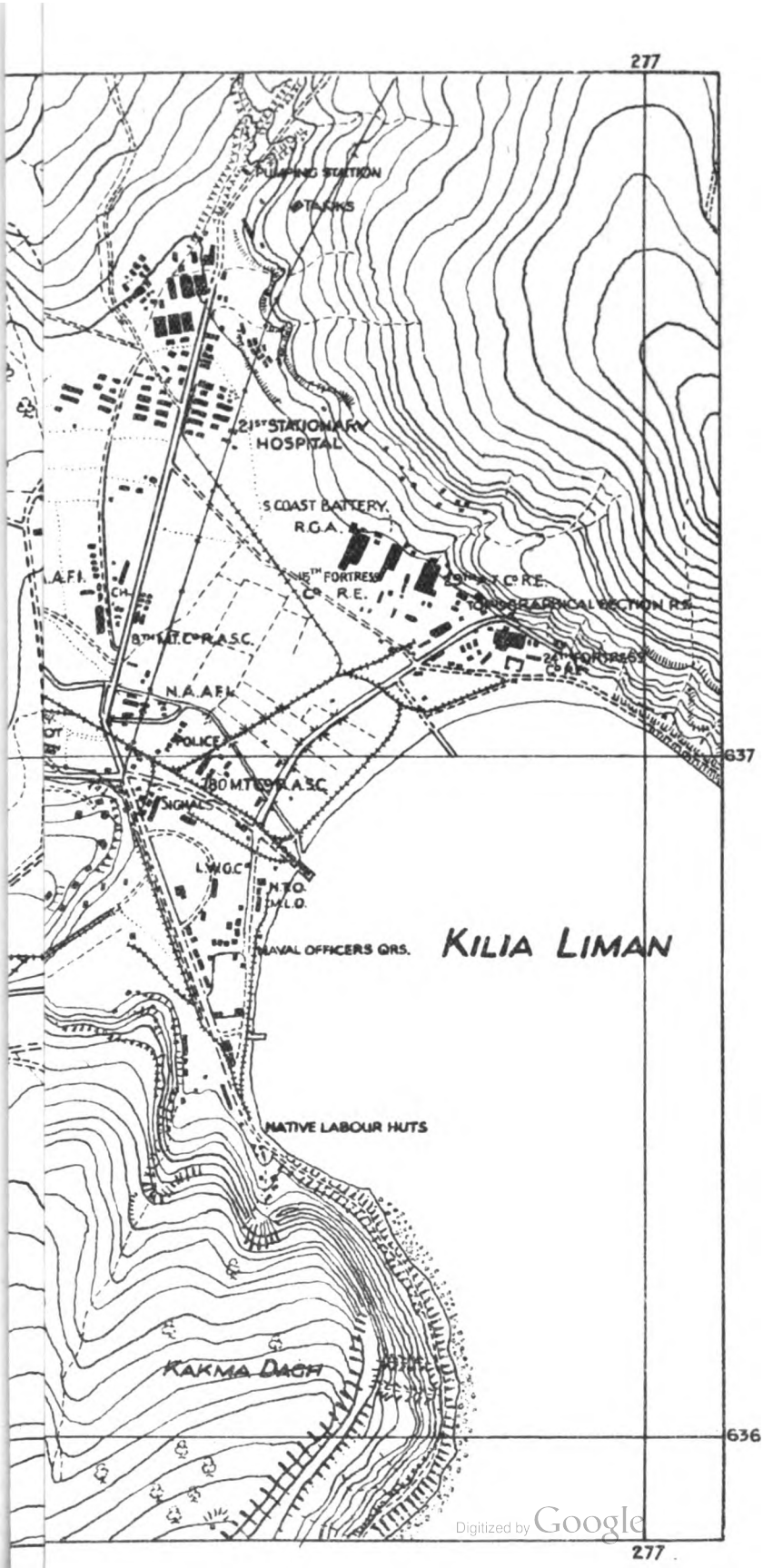

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Boghali Kal
Ova Farm
Nagara Burnu
Kia Ustu
Tuzla (Salt) Lake
Kavak D.
Coal Depôt
Kuzlu Well
Sevran Well
Yaighun D.
Tekke
m Burnu Tepe
Kusa Burnu
Haji Sidki Eff. Barracks
EUSBEK
Haji Sidky Eff. Farm
Kutchuk Kir Sirte
Anatolu Mejidieh Fort
Geuz Tepe Spr.
Biyuk Kir Tepe
urnu
Rashid Farm
Yalamun Dere
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Chai
Kir Well
Hamidieh Fort
Sarayjik Bridge
Inji Baba Tekke
Zibhane
SARAYJIK
Tenez Tepe
Huzur Eff. D.
Sivri Kaia
Kizil Chala Tepe
Sari Siglik
Metres

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by land, and consequently were handled four times instead of twice. In the winter storms sea transport by ferry and lighter was most precarious, and stores were frequently carried beyond their destinations or brought back undischarged. In the middle of December, the Officer i/c R.E. Stores moved down to Kilia, and supplied Chanak and Gallipoli direct from there, which was a marked improvement. After April, however, stocks were kept very low, and any large consignment or special stores had to be bought in Constantinople, entailing considerable delay.

The only item procured in any quantity by local purchase was timber. Large supplies of rough scantlings were obtainable locally at very reasonable prices.

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PROFESSIONAL NOTES.

USE OF SILICATE OF SODA IN CONCRETE.

AN article in the July number of *The Concrete and Constructional Engineering Journal* calls attention to the use of silicate of soda for hardening the surface and for waterproofing concrete.

There are several forms of silicate of soda on the market, the most common being known as "water-glass."

The forms of silicate of soda in commercial use contain soda (Na_2O) and silica ($Si\ O_2$) in ratios varying between 1 : 4 and 2 : 3.

For the treatment of concrete a silicate of soda with a high proportion of silica, *i.e.*, with three or four parts of silica to one part of soda, should be obtained. Such silicates of soda are called "neutral" or "high-ratio" silicates; water-glass is not one of these.

The general action of silicate of soda on concrete is described as follows:—

> "When a dilute solution of 'neutral' silicate of soda is applied to concrete some absorption occurs according to the degree of porosity of the concrete. The surface of the concrete is thereby hardened and the pores of the concrete are, to some extent, filled. The silicate of soda slowly undergoes chemical changes and insoluble products are formed which act as a permanent filling near the surface and form a dense layer, perhaps $\frac{1}{8}$ to $\frac{1}{4}$ of an inch thick, so that the concrete is more resistant to abrasion and more impervious to water and other liquids."

The silica combines with the lime set free during the setting process of the cement and forms silicate of lime, which is one of the compounds contributing to the strength of cement.

A solution of silicate of soda can be purchased, containing approximately 30 per cent. of silica and 9 per cent. of soda. This should be diluted by adding four volumes of water.

The concrete should be clean, dry, and free from grease before treatment. Three coats of the dilute solution are given, the surface being allowed to dry between each coat.

The solution can be sprinkled through the rose of a watering can and should be brushed over the surface with a soft broom.

For waterproofing concrete it is recommended that four or five coats be given with a more diluted solution.

Floors and roads treated with silicate of soda have a hard surface and are free from abrasion. Their surface is not rendered slippery.

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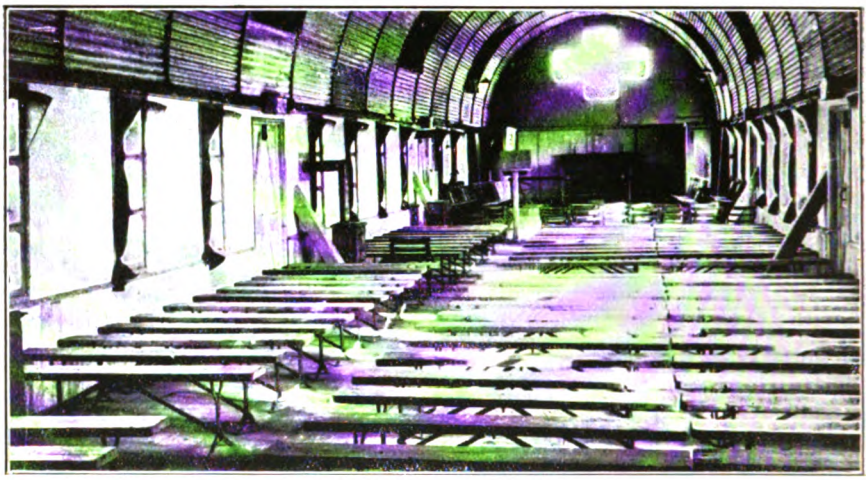
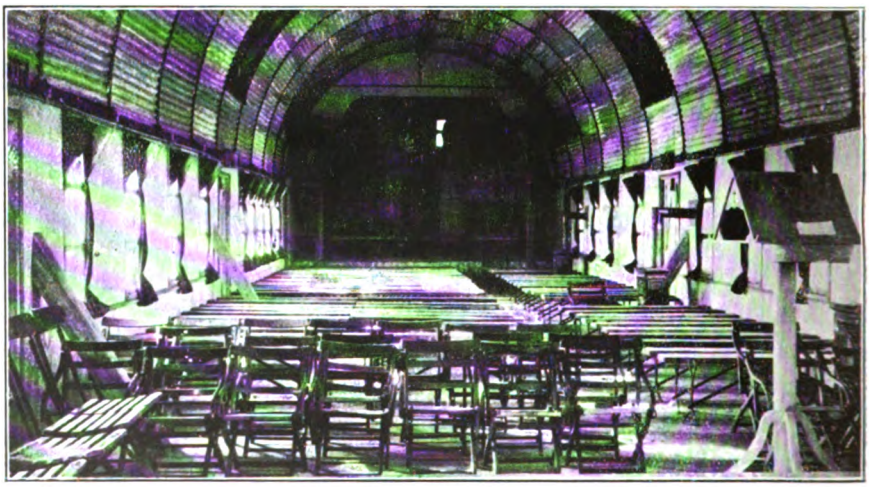
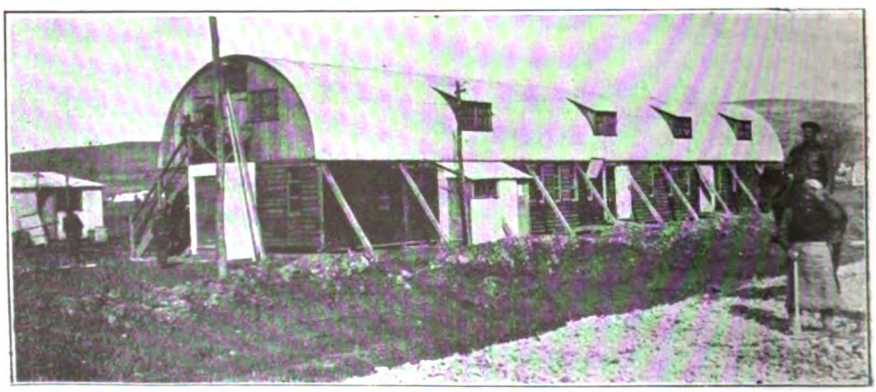
KILIA INSTITUTE.



Interior facing South.



Interior facing North.



Exterior View.

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Building blocks may be hardened and rendered denser by pickling in a dilute silicate solution

The whole process is inexpensive; one gallon of silicate diluted with four gallons of water will cover 1,000 sq. ft. surface with one coat.

D.K.E.

KILIA INSTITUTE.

By Colonel-Commandant A. G. STEVENSON, C.B., C.M.G., D.S.O.

IN December, 1922, instructions were received to construct a hall at Kilia suitable for use as a church, cinema and entertainment hall, with the view of providing some moral and mental stimulus for the troops, who had been living for some time under somewhat trying and depressing climatic conditions.

The following requirements had to be met :—

1. Sufficient height and size to allow cinema pictures to be seen over the heads of men sitting in front.
2. Dressing rooms for concert parties.
3. A screened-off altar and vestry.

As a result of (1) and (2) a level floor was decided on, with a stage at one end and an altar and vestry at the other. It was arranged for the cinema to project its pictures on to the back of a transparent drop, which took the place of the stage curtain.

The available skilled labour at Kilia was busily engaged on other urgent services, so it was decided to make use of units of the Nissen and other portable-type huts. The resulting building is shown in the attached *Photographs*.

In the main it consists of two 60-ft. Nissens superimposed on walls of Malta hospital hutting. The walls were strutted both inside and outside, and each outer strut was enabled to act as a tie, if necessary, by means of two iron straps at the top, which, passing over and down, secured the wall plates. The feet of these struts were also tied down to the transverse bottom bearers, on which the ordinary Nissen floor was laid. Dimensions are :—120 ft. long, 20 ft. wide and 18 ft. to highest point.

Seating accommodation, considered comfortable, is 250 to 300, but the chaplain prefers a congregation of 350 to 400, which he sometimes gets.

Congregations at religious services face north, while audiences at either concerts or cinema performances face south.

The acoustic properties of this somewhat quaint building prove remarkably good.

The work was carried out by the 24th Co., R.E. The M.F.W. was Q.M.S. Fryer, who was partly responsible for the design.

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MEMOIRS.

COLONEL CHARLES WILLIAM ROBERT ST. JOHN.

THE many friends of Colonel St. John will be grieved to hear of his sudden death at Simla on 27th June.

Accompanied by his wife, he had gone out to India to pay a visit to his son, and to make the acquaintance of his grandson, whom he had not yet seen; and, in addition, had purposed to visit Mission Stations both in India and China, where he had a large number of friends in connection with both the Church Missionary Society and the China Inland Mission, of which bodies Colonel St. John was a Member of Council.

He was known and beloved by hosts of his brother officers, many of whom had first met him when Assistant Instructor of Survey at the S.M.E., from 1888–93, and in subsequent years many others had enjoyed the genial hospitality of Colonel and Mrs. St. John when stationed at Gibraltar from 1897–1902, and also at Hong Kong from 1909–14, where he was employed as Chief Engineer on becoming a Substantive Colonel, after a term of four years at Belfast as C.R.E.

On leaving China in 1914 he came to England on half-pay, and on the outbreak of the War, in August, 1914, he was sent to France, and subsequently became Chief Engineer at Plymouth to the date of his retirement on August 30th, 1916, having served for nearly 39 years, a bad heart attack preventing his undertaking any further military duty.

He came of a line of soldiers, both his father and grandfather having been Colonels before him.

During his long career he was conspicuous for his sense of justice and perfect uprightness, his unswerving strength of principle being evidenced by the conscientious performance of every duty, seeking in all that he did to do it to the glory of God.

He leaves a widow, a son (Major in R.A.S.C.), and a daughter (the wife of a Naval officer) to whom the sympathies of the Corps will be extended.

J.W.

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Lieut. J. W. M. Dickson, R.E.

Photograph by W. CROOKE, 103, *Princes Street, Edinburgh.*

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LIEUT. J. W. M. DICKSON.

THE Corps has lost a most promising and gallant officer by the murder of Lieut. J. W. M. Dickson on the 11th November, 1922, in the Khaisora Valley, North Waziristan.

James White Melville Dickson was born on January the 25th, 1899, at N. Shoebury, the son of Walter George Dickson. He was educated at Bedford and passed into the "Shop" in June, 1917. In his senior term he was a Corporal; he also boxed for the "Shop."

He was commissioned in September, 1918, and joined the S.M.E., where, after two months on the square, he was one of the seven of his batch posted to Signals. After serving in Signal Depôts in England he sailed for India in February, 1920, and was posted to the Signal Depôt at Wellington, whence he was transferred to the Q.V.O. Sappers and Miners at Bangalore in May, 1920.

From that date until his death Dickson was mostly on the frontier. He spent some months with No. 66 Company in the Khyber, returned to Bangalore for a few days and then joined No. 14 Company in Waziristan, in October. After seeing the Wana operations with No. 14 Company, he joined No. 96 Company at Dardoni in February, 1921, being transferred to No. 13 Company, which came up in relief in October of that year.

With No. 13 Company he took part in the advance to Datta Khel in November and December, but went home on five months' leave, rejoining No. 13 Company at Dardoni on the 1st May, just when the Razmak road was being started.

He was the officer selected from the S. and M. Companies to be lent to the M.W.S., for the work of reconnaissance and construction on this remarkable road.

The history of the making of this fine motor road into an enemy country, in advance of the troops, will be found written elsewhere, but the outstanding personalities in this story were three Sapper officers: Major Deed, Lieut. Jefferies, and Dickson, who was killed. Deed and Jefferies received the D.S.O. and M.C. respectively as immediate rewards.

Jefferies and Dickson were in charge of the advanced sections. They went about the country alone in shirt, shorts, *chaplis* and revolver, protected by two or three *badraggas*. They feared nothing, and were taking risks which were only justified by the necessity for rushing on the work.

In December, 1922, the construction had reached the middle of the Khaisora Valley, and Dickson was employed on survey work for the road up the Razmak Pass. He was living then at Tamre Oba, and had just been joined in his sector by a young pioneer officer, Lieut. Bromhead.

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About this time the Mahsuds were getting annoyed at the work advancing into their own special country, and one, Musa Khan, an intractable, had already threatened to do something to stop the work. On the 12th December one of his gangs ambushed Dickson and Bromhead in the evening as they were returning to camp, and shot them at a few yards' range. Dickson fell, with a bullet through the chest, Bromhead was hit when pulling Dickson behind a rock, and then Dickson was hit again in the head. The assailants were then driven off by the *badragga* escort, who brought Dickson's body in.

This murder could not be avenged at the moment, but it formed the *casus belli* for the occupation and destruction of the Mahsud stronghold of Makin, which was carried out by two Brigades after Razmak had been reached.

Dickson was of the best type of young Sapper officer. He knew his job, he devoted all his time and thoughts to it, was popular with his brother officers and with his men, whom he drove hard, and was absolutely fearless. He is one more of the gallant fellows the Corps has lost on this turbulent Border.

C.M.W.

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BOOKS.

THE DEFENCE OF INDIA.

By "ARTHUR VINCENT." (Humphrey Milford. Oxford University Press, Bombay. Price, Rs 2.)

THIS little book forms the second volume of a series under publication for dealing with the problem of India. We welcome the series as a whole and trust that these books may be read and re-read, not only by ourselves but by the educated Indian, so that the problems that have to be faced may be treated intelligently, courageously and with balanced minds.

The book under review gives a brief but clear exposition of the problem of Imperial Defence in so far as India is concerned. It cannot, therefore, be set aside as one that is only for experts. It affects the whole British Empire. It should form a very wholesome instruction to the people of India, and one which should be carefully considered by them. It may not be pleasant to be told that there is no early prospect of any reduction of expenditure in the cost of the defences and upkeep of military forces in their country, and a necessity for a still further expenditure on Naval defence. It is pointed out, further, that the present small (£100,000) annual contribution of India towards the cost of the British Navy, her first line of defence, is insufficient, and that, owing to the present circumstances, danger of attack, if any, comes from the East. This is realized in England by the necessity for a large expenditure on Singapore which has been recently ventilated in the Press. Such expressions as these—taken from the book—"The centre of gravity of possible naval activity is, therefore, now no longer in European seas, but is in the East and the Pacific," and, "The ultimate goal may be an Indian Fleet, maintained from India and based immediately upon Singapore," need to be taken to heart by Indians themselves.

The book is divided up into chapters dealing with the various frontiers and their respective problems, a large number of the chapters being taken up with the north-western frontier. This has necessitated the much-debated question of the forward policy on the frontier and measures for protection against the Bolshevist being explained, which the author of the book, whom we understand is an officer of the Corps, has treated concisely but clearly and with good common sense. We now hold the main routes for an invading army from the west right up to the Durand line, but these are narrow salients flanked by fanatical, well-armed and still undisciplined tribesmen, who are quite capable of forming a very serious menace to bodies of troops utilizing the valley routes, causing us to deal not only with potential enemies advancing from the west, but with others within our own borders, thus necessitating the distribution of our forces when we should have them all concentrated

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at decisive points. The writer is of opinion that in course of time, as a military measure, we shall have to occupy the whole borderland up to the Durand line, and the sooner the better. This is a very large and debated question, involving political as well as military interests. To the military mind there can be no two doubts as to what is right, and by the opening up of forward territories within our " so-called " sphere of influence, by roads, railways, etc., we would be paving the way for far more effective military operations westwards.

This would undoubtedly entail a large outlay and it would be difficult to finance it. At the present time, however, India has to set her own house in order. Internal disputes, constant friction between religious parties, who can never have a common foundation until they construct one for the well-being and welfare of the people, of whatever class and creed, and not for a small selected body of educated Indians and so on, are now hindering progress. It is intended that Indians must realize that, until India can regulate herself and keep law and order within her own border, she must leave her defence in the hands of those who study the subject from the broadest point of view, and accept their decisions, though they may be unpalatable to their minds and expensive.

It is important to bring to light the fact that the tendency of Indian politicians is to complain of the amount voted for military purposes in the Central Budget, which amounts to about 59 per cent. of the total budget. It is considered, however, that the Provincial Budgets should also be included in this assessment, as all must share in the benefit of military protection, in which case the proportion would be reduced to some 30 per cent. In any case, military expenditure brings in a return, as British officers and troops spend their money freely in the country, a large number of Indians are fed and housed by enlisting, and the money expended on the many works services all over the country benefits the Indian tradesman and labourer to a large extent. This is often lost sight of by those who favour a reduced military expenditure.

We cannot conclude without commenting on the inefficiency of the map at the beginning of the book. It gives only a very sketchy outline of the Frontier, but this is probably due to the fact that a really good map would materially affect the cost of production. Readers are, therefore, advised in studying the book to have for reference a really good map.

S.

VAUBAN.

Par DANIEL HALÉVY. (Paris. Grasset. 6·75 francs.)

WE picked up this book with the pleasure of anticipation, expecting to fill a gap in our ignorance, for it struck us, on seeing it in a new book list, that we had read very little about the greatest of French Engineers. Unfortunately, it turns out that very little is recorded about Vauban. The author tells us in the opening pages :—

" This man, whose name is so widespread, what do we know of him ? What was his style ? What was the tone of his voice ? We are entirely ignorant. Vauban is a symbol whose material form escapes us. In

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the century in which he moved and proved his genius, Vauban passes by, but is scarcely seen." Apparently none of the diarists mention him.

Later, M. Halévy says :—

"The written work of Vauban is similarly disseminated and unknown. And it will so remain for ever." Practically all that can be found is a mass of correspondence full of technical details :—"From the far end of Catalonia Vauban instructs a contractor, who is building a bastion in Flanders, what wood he is to use for the piles in the foundations ; from the centre of Brittany he directs the contractor, who is fortifying a hill in Savoy, what sand he is to employ for the mortar."

The book, therefore, for the most part, deals with the general history of the period in which Vauban laboured. But a certain amount of biographical detail has been collected, and Vauban himself, in 1700, wrote an *Abrégé* of his services.

Sébastien Le Prestre—the name Vauban is territorial—came of a family of small landed proprietors. He was born 4th May, 1633, in his father's house, in the parish of Bazoches in Morvan. At the age of seventeen he took service under Condé, then in feudal rebellion, as a "Cadet" in the Régiment de Condé. "Having a good knowledge of mathematics and fortification, and not drawing badly," as the *Abrégé* states, Condé employed him as apprentice-engineer on the fortification of Clermont-en-Argonne. and later at the siege of Sainte Menehould. After about two years' service, whilst out riding, he was taken prisoner, and, in the easy manner of those days, transferred his services to his captors. He was sent a second time to the siege of Sainte Menehould, this time to capture his first master, who was invested there. In 1655, at the age of 22, he received a commission as Engineer-in-Ordinary to the King, with Louvois as his chief ; his bravery, rather than his attainments, seems to have brought him to notice. Then comes a long blank. In 1667 we find him accompanying Louis XIV. in his Flanders campaign as his Chief Engineer. Henceforward his life is one of constructing fortresses and besieging them ; in one letter preserved he speaks of "the wandering life that I have led for forty years or more."

In 1703, at the age of seventy, Vauban was created a *Maréchal* of France with nine others ; all of those names, except that of Tallard, famous for his defeat by Marlborough, are unknown. But the promotion practically put him on the shelf. As the King told him, "to take towns is beneath your dignity." The business of a Marshal was to command armies, and there was no army for him.

In this enforced leisure he turned to many plans. One of them was the construction of the La Bassée-Aire–St. Omer Canal, now so well known to the British Army. It was to serve the double purpose of a defence line and a means of communication. The local authorities were afraid that they would have to find the money to construct it, and opposed the project. It was not carried out until 1770.

Another of the activities of his old age brought him into serious trouble. He was of a kindly and benevolent nature and had, in his continual journeying through France, seen the misery of the lower classes, and had, in 1700, gone to the length of personally bringing their down-trodden and over-taxed condition and the malefactions of the *fermiers-généraux*

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to the notice of the King. Now in 1706 he was moved to write and print a pamphlet—or, rather, a book—on taxation, which he had long meditated, under the title of *La Dixme Royale*. It advocated that all classes should be taxed, the farming of taxes abolished, and an income tax of one-tenth levied direct for the King. He was too much in advance of his times. The circulation of the book was prohibited and its author narrowly escaped arrest. He died sixteen days after the issue of the decree that condemned his work.

J.E.E.

LA GUERRE EN ACTION, UN COMBAT DE RENCONTRE, NEUFCHÂTEAU (22ND AUGUST, 1914).

By COMMANDANT A. GRASSET, with Preface by GENERAL BUAT. Octavo, with five Plans, of which four are outside the text. Published by Berger-Levrault, Paris, Nancy, Strassburg. Price, 5 francs, net.

AN account of the terrible day on which the Colonial Brigade of Paris held in check the whole 18th German Reserve Corps. Although only one against six, the "Marsouins"* remained masters of the battlefield. Strict historical truth, based on numerous documents, only serves to bring into view the poignancy of the drama, and the heroism of the actors. The complete reconstruction of every phase of the battle, including the action of staffs, companies, batteries, sections, and even of patrols, affords a useful study for officers, and, for the non-professional, an opportunity of realizing the actual emotions of a battle.

A. R. REYNOLDS.

L'ARTILLERIE: CE QU'ELLE A ÉTÉ: CE QU'ELLE EST: CE QU'ELLE DOIT FAIRE.

By General HERR. (Berger-Levrault. Price, 18 francs.)

IN May, 1916, after the defence of Verdun, the writer of this book, General Herr, was appointed by General Pétain to co-ordinate the experiences of the artillery during the defence, and to form for the centre group of the French armies a *Centre d'études d'artillerie* for the mutual instruction of the senior officers of that arm. The idea was taken up by the G.Q.G., and in June the course was thrown open to all the French armies. Later on, in January, 1918, under a new organization, General Herr was appointed Inspector-General of Artillery, and, in addition to the general surveillance of all the artillery in the armies and the command of the general artillery reserve, he was accredited to the Ministries of War, Armaments and Marine, and conducted all questions concerning artillery between the Commander-in-Chief and the Government. He, therefore, writes with authority, but at the same time his book is thoroughly readable and is not too technical to be beyond the interest

* Commandant Grasset, D.S.O., in reply to the Acting Secretary, has very courteously given the following explanation of the word "marsouin":—Le "marsouin" est un cétacé, du genre des phoques (*seals*), qui vit à la fois dans l'eau et sur la terre ferme. C'est pourquoi on a donné depuis longtemps chez nous le nom de "marsouins" aux soldats de l'infanterie coloniale qui vont combattre sur terre ferme dans les colonies lointaines, après avoir traversé les mers.—ED., *R.E.J.*

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of officers outside his own arm of the Service. The French, according to General Herr, suffered from possessing an exceptionally good field-gun ; they thought it could do everything, and it was sheer good fortune that the war found them ready, at any rate with the designs of heavier pieces for use in the field. Still, he admits that the French never recovered the lost ground and that their guns were always out-ranged by the Germans. They are not likely to make the same mistake again ; in fact, we are given a list of eight principal missions of artillery in a future war, almost all of which require special types of artillery weapons. They are the following : (1) guns to accompany infantry—light, shielded, and mechanically drawn ; (2) guns for the direct support and protection of infantry—to include a field howitzer, which their divisions have not hitherto possessed ; (3) guns for the destruction of the enemy's organized forces ; (4) destruction of obstacles ; (5) counter-battery ; (6) *interdiction* of the approach of the enemy's reinforcements, supplies, etc. ; (7) anti-tank ; and (8) anti-aircraft. The General thinks that, as the Middle Ages were the era of cavalry, and as infantry has been the queen of the battles of modern times, so artillery has now come to the fore and the next war will find it the principal arm. But its preponderance will be only temporary, until a new arm comes to take its place. Students would find in this book a useful collection of artillery technical words, as, for instance, *régimage*=calibration.

THE PROBLEM OF ARMAMENTS.

A book for every citizen of every country, by ARTHUR G. ENOCK, M.Inst.Mech.E. (Macmillan & Co. Price 6s.).

By the publication in many languages of this book, which contains carefully collected statistics of the cost, waste and destructiveness of armaments, and quotations from speeches on the subject of their restriction, the author hopes to convince his readers of the fallacy of the maxim " If you want peace you must prepare for war." Sir F. B. Maurice is quoted as having said " If you prepare thoroughly and efficiently for war you get war." At the same time it seems to be very difficult to make any practical suggestions on the subject of disarmament. The control and restriction of the manufacture of war-like stores by private firms is a practical suggestion, but it is doubtful if the same can be said of the proposal to form an international fraternity of all chemists, who would interchange their discoveries and so prevent the surprise which might be caused by any nation which possesses a new and exceptionally virulent poison.

SOME MILITARY CONVERSATIONS AND OFFICIAL COMMUNICATIONS IN FRENCH.

Edited by Lt.-Col. J. H. GETTINS, D.S.O., Army Educational Corps (Gale and Polden. Price 3s. net).

The book is arranged for the use of the Sandhurst cadets. The conversations are given in French and there are useful technical vocabularies, English–French and French–English.

F.E.G.S.

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MAGAZINES.

MILITÄR WOCHENBLATT.

15th January, 1923.—As was to be expected, the leading article of this number, under the title "Germania sub pondere crescit," deals with the advance of the French into the Ruhr. "With gnashing of teeth one reads the ignominious reports from West and East." That from the East is the occupation of Memel by the Lithuanians, but apart from its mention here the incident is not again referred to. "Spontaneously the hand flies to where our sword used to hang. It grasps at the air: we are weaponless! No war in these days can be waged with flails and hay-forks." And so on, reminding the Germans that this is not the first time that they have slid down into the trough of the wars, but that they have always worked their way out again. The enemy, it says, by his audacious invasion has torn up the peace treaty (the word "Diktat" is invariably used now) and has forced the Germans to a war of liberation. Two allies they claim, right which is on their side, and the interest of world economics. Therefore their right to a revision of the treaty must be proclaimed abroad, while at the same time they prove that this, too, is needed for the sake of the economic situation of the world. "Even to-day the respectable business community on this side and on that side of the sea sees clearly that 'Versailles' was a criminal folly." Only it lacks the conviction that the Germans must be helped. The article ends by preaching the need for co-operation of all parties, requiring the spirit of August, 1914, toned down to a "sober enthusiasm."

General v. Kuhl reviews at considerable length the second and third volumes of *Reminiscences* of Field-Marshal Conrad v. Hötzendorf, the first volume having been reviewed last May, from which the outstanding fact appeared that Conrad was an unconditional believer in a "preventive war" to meet the dangers with which the monarchy was threatened. Vol. II. deals with the years 1910–1912, and Vol. III with 1913, and the first half of 1914. The great value of these books is said to be the reproduction of documents arising from his correspondence with the Foreign Minister and other authoritative personalities.

After dealing with the first and second Balkan wars, the reviewer details at some length the proposals for Italian co-operation with the Triple Alliance in a war with the Triple Entente, which in January, 1913, were said to comprise an advance by 16 Italian divisions from western Italy in the direction of Lyons, and simultaneously a landing on the south coast of France iven local command of the sea. In September, 1913, General Pollio, Italian C.G.S., declared, in conversation with

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Conrad and Moltke at the German Grand Manœuvres, that Italy could only place four or five Army corps in the field against France, as the rest were too exhausted by the Libyan campaign ; finally, however, he promised to place two cavalry divisions and three, perhaps five, infantry divisions, at disposal for transport through Austria to the German southern flank. In February, 1914, it is said that the King of Italy had given his consent to the dispatch of a force of this strength under the command of General Zuccari to the Rhine in the event of war ; the corps were to be ready to move on the 19th day of mobilization. General Count Waldersee was soon, in February, 1914, convinced of the reliability of these promises, and General v. Moltke too repeatedly assured Conrad that he firmly believed in Italy's good faith. Conrad, on the other hand, seems not to have shared this belief, while Count Schlieffen considered the addition of Italian corps on the German left flank on the upper Rhine as an " illusion," nor did he believe in an Italian attack across the Alps against France. The Austrian heir to the throne, Archduke Franz Ferdinand, looked on Italy as the chief enemy and told Conrad that they must win back Venice and Lombardy !

Of greater importance are the reliable data which Conrad gives concerning the agreements with General v. Moltke about operations in the event of a great war. After dealing with the general scheme, with which everyone is now familiar, it is said that Moltke expressed the hope of reaching a decision in the West in three to four weeks, and of then sending strong forces to the East to force a decision there in co-operation with the Austrians. The reviewer admits that this was an optimistic view. In any case, in the early part of 1914 the Germans undertook to employ 12 " and perhaps more " divisions in East Prussia, and contemplated the addition to that force of further troops (2nd line) soon after the opening of hostilities. But all the negotiations tend to show that the German G.S. only met Conrad's wishes for the strengthening of the Eastern force with reluctance. In May, 1914, at a Conference at Karlsbad, Moltke declared that they hoped " in six weeks from the beginning of mobilization " to have polished off France, or at least to have got on so far that they could transfer their main forces to the East. The reviewer then says that the impression is not to be avoided that a great deal was promised to Austria Hungary by Germany, and then proceeds to show that the former were unwise in expecting so much and therefore should not have risked the offensive in Galicia.

1st February, 1923.—The 24th January being the anniversary of Frederick the Great's birthday, General Ludendorff contributes an article entitled " Echoes on Frederick's Day." He reminds his readers that before the war this day was celebrated only in military circles in Berlin ; speeches were delivered dealing with his battles and wars. " This was not enough. . . . Certainly the old Fritz was a popular king, people had some notion of his greatness, but they did not understand how to educate a people after his model, and to show them with what heroism and moral grandeur this great monarch, commander and man, with his heroic host and his Prussian people, withstood the assaults of the world in a seven years' struggle, and what circumstances alone contributed to his salvation, in order to prepare them for the

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coming war in which Germany would have to preserve its life in face of the enemy's will to destroy, just as the king preserved his country's life after the second Silesian War." After this exhausting sentence, Ludendorff proceeds to show that ever since 1870 they knew this decisive war was coming, but Prussianism was more and more withdrawing into the background, and the general opinion was that the country must just hold what it had got. From this sprang the thought that a less effort was required than for the achievement of definite aims.

" This dangerous fallacy, combined with our pacifistic, international, thoroughly un-Prussian way of thinking, finally produced the result that our armed forces fell far below what was possible, and false ideas about our strength and about the nature of the coming war took firm hold of the whole nation, even though Bismarck's policy of alliances had been given up." Thus, presumably, Ludendorff sets out to prove that the war was lost by lack of statesmanship before it was begun.

After quoting a Chinese sage on the lack of adequate preparation for war, he then turns to Frederick the Great's action after the second Silesian war, bringing his army up to an unprecedented height of efficiency. Then follow the seven years, " a heroic epoch with the king as hero," and we are treated to quotations from Frederick's reports after various disastrous battles, where his situation goes from bad to worse till at last the Empress of Russia dies and her successor makes an alliance with Frederick and Prussia is saved.

After the war Ludendorff observes that the King's policy for the reconstruction of his country was not " the art of the possible " but " the art of dealing with all suitable means always in conformity with his own interests " ; he then recounts the blessings which Frederick bestowed: selfless work, self-discipline, willingness for sacrifice, orderliness and so on. He was the protector of German princelings ; Bavaria he saved from the oppression of Austria ; his princes' league was the forerunner of the empire of 1871. After the collapse of 1806–07 it was the memory of the " hero-king " that inspired Prussia to her resurrection. And so he comes to the point of the article, urging his countrymen to recollect and imitate the great qualities which were, he says, inspired in the German nation by Frederick, and to work for the preservation of Prussia. " Without a strong Prussia as leading power there can be no veritable Germany."

15th February, 1923.—Mr. Lloyd George's articles in the papers have incited the *M.W.B.* to the publication under the title, " The Best Army in the World," of a lengthy attempt to prove Germany's innocence in the matter of the Great War. The writer says that Mr. Lloyd George recognizes as the cause of the world misfortunes of to-day—since Germany's disarmament—the utterly unjustified, exaggerated armament of France and her efforts at the hegemony of Europe. But at the same time Mr. Lloyd George seeks to impute the cause of the outbreak of the Great War to the existence of the German Army of 1914, according to Foch the best army which the world has ever seen. The writer first observes that Foch's dictum about the German army, " no matter how absolutely correct it is," was only pronounced after the outbreak of war. Before the war they thought otherwise in France, and quotations are

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given in support from the writings of the French colonel, Boucher. " Kaiser William II.'s love of peace after ' Morocco ' and other political transactions was exposed in the French press as fear, which the *Temps* converted into the oft-repeated form—' *Guillaume a peur, il a simplement peur.*' " The Belgian ambassador in Paris is then quoted as labelling the French as chauvinistic, and saying that people are to be met (in March, 1913) who assure one that an early war with Germany is unavoidable. The same ambassador is quoted twice more with even less effect, and then the writer says: " It is remarkable, from the point of view of the world's history, that the same ambassador, shortly before the outbreak of war, *at a time when no man in Germany—politician or soldier—even remotely thought of war*, made report . . . " and then follows the quotation to the effect that in France those people, experts, who, two years previously, evinced lively fear at the mere mention of possible difficulties between France and Germany, now adopt a different tone; they assert that they are sure of victory, and that the French Army can hold the Germans in check till Russia has mobilized and is ready to concentrate her troops for an attack on her western opponent. The above italics do not appear in the *M.W.B.*

The writer then quotes the Russian ambassador in London as saying in February, 1913, that all the powers are striving for the maintenance of peace, but that France is the one that would most philosophically go to war, due to complete confidence in her Army.

The Anglo-French naval agreement secured the transport of the French Colonial Army. A " French statesman " is then quoted as saying that the French artillery would soon silence the German. In the French Army before the war they believed not only in the admitted, but much exaggerated, superiority of the French field-gun, but also—after the Napoleonic example—in the superiority of the French soldier, his " *élan*," and his superior aptitude for the conduct of modern war. " The bitter experiences of war have then taught the French politicians and military leaders, including Mr. Foch." The same French statesman is then quoted as declaring that the participation of the English was actually settled down to the smallest details, though no written agreement existed, just as though a treaty had been concluded between the two countries; he is quoted as even giving the ports of disembarkation in France. So when Mr. Lloyd George says that " no country can withstand attempting an easy triumph which has been offered for two generations," the writer remarks that with regard to that he has proved to any unprejudiced observer that this can only be laid at the door of France, Russia and England, who likewise believed in a quick victory by the superior forces. On the other hand, responsible military and political circles in Germany, while convinced of the superior quality of their own army over the French or Russian, were well aware of their considerable numerical inferiority !

The writer then takes up Mr. Lloyd George's statement that fleets are by their nature means of defence, and alone can never conquer a country or seize its capital. Why, then, he says, did the English before the war always regard the German fleet as the greatest danger of attack? How is it that England to-day possesses a colonial empire, the like of

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which the world has never seen, with which neither the ancient Roman, nor the empire of Charles V., on which the sun never set, can compare? He says that Blake and Nelson would turn in their graves if they heard the assertion that the English fleet had become a means of defence. A speech of Lord Lee of Fareham's on 2nd February, '05, is then quoted, when he says that he hopes that in case of danger the British fleet will be in the position to get in the first blow, even before the other power is aware that war has been declared. " That is the nature of the English defensive fleet " !

Further on the writer says, " It was just the regrettable fate of the political situation of the world in 1914 that the English statesmen, through Edward VII.'s policy, had been directed into false channels, had forsaken the old clear lines of English policy and believed and feared Germany's designs on the political and economic hegemony of the world." The French book, *La guerre qui vient*, published in 1911, is then quoted to show that the economic struggle between England and Germany had inevitably to lead to war, and as an American has said, " The war was not made in Germany, but the ' Made in Germany ' was the cause of the war."

French imperialism and Russian chauvinism were strengthened by the Entente; by it England placed herself in the hands of the most turbulent and most ambitious powers of Europe ! Finally, it was the panslavistic politicians on the Neva (Sassanow, Iswolski) who put the match to the powder barrel, " and no really great statesman was available, who could still arrest the dire fate of Europe." Anyway, concludes the writer, the ' best army in the world ' was not to blame.

This wonderful composition is, then, to teach the English statesmen a lesson. After four frightful years of war and four similarly bitter years of peace, England's world power, thanks to English statesmen, has suffered heavy loss through the treaty of Versailles. France is now the ruler of Europe ! Changes in the means whereby war is waged took place during the Great War, and the " frightful effect " of these changes, in spite of the strongest of fleets, signifies the abolition of England's insular unassailability !

France, by Germany having been rendered defenceless, has been given liberty " to pursue unhindered her imperialist and militarist aims of the hegemony of Europe and the world, in both a military and an economic sense."

Mr. Lloyd George's Versailles policy of the " knock-out," which lacked any trait of great statesmanship, is now bearing its sorry fruit to the harm of England and of the whole world. Poincaré is once again *en marche* !

1*st March*, 1923.—The leading article of this issue reviews Dewar and Boraston's book, *Sir Douglas Haig's Command*. After observing that the book has attracted the greatest attention in the military and political world of the Allies, the reviewer proceeds to state that the object of the book is to prove that the military genius of the English commander-in-chief and the high fighting value of the British troops were responsible for turning the decision in favour of the Allies in all the most difficult situations on the Western front, and finally brought about the victory

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over the German Army. The reviewer then quotes a number of facts disclosed by the book, but without comment. He says that the French in general come badly out of the story, whereas the Americans gain a better verdict. "The performances of the German Armies and of their leaders—particularly Ludendorff—meet with high recognition." He notes with satisfaction that the British losses from March, 1918, to August, 1918, and the German losses from the latter date to the Armistice were approximately the same, *viz.*, about 350,000. The difficulties existing between the Government and G.H.Q. are then referred to, concluding with the remark that Lloyd George only believed in one military genius, namely, Marshal Foch.

" History will assuredly not count Field-Marshal Haig as among the greatest commanders, in spite of the military deeds and successes depicted and made conspicuous in this interesting book. . . . He fought numerous battles with great superiority, particularly in *matériel*, and nearly reached a final success, as in Flanders and at Cambrai; but he did not understand how it was to be consummated and exploited." The battles of attrition of 1916 and 1917, he says, can only be designated as " ordinary victories," to use a phrase of Schlieffen's. " That a great success in a similar situation was possible is proved by the German offensives of 1918. If, nevertheless, the English Army under Haig's leadership was destined to wrest great successes in the autumn of 1918 from the German Army, which was no longer fully fit for fighting, the reason is not to be found in the superior genius for leadership of Field-Marshal Haig, but in other well-known causes." And the reviewer leaves it at that.

E.G.W.

HEERESTECHNIK.

(*May and June*, 1923, *numbers.*)

THE *pièce de résistance* of the official parts of these two numbers is the continuation of Capt. Justrow's treatise on the theoretical conditions affecting the life of barrels—gun, trench mortar, rifle and pistol—and the effect of wear on fire control. By this time the treatise has appeared separately in print and has been added to the Corps Library. The two portions in question are condensed mathematical investigations illustrated by Formula and Table. Extracts would be meaningless.

Doctor G. Lechner contributes an article on " stops " in field-glasses and telescopes generally. He shows where, in different combinations, these stops should be placed, in order to cut out both reflected light and all such rays as do not contribute usefully to the required image.

A short official statement explains a " simplified book- or ledger-keeping" now being introduced. It is on the " Tally " or " Stock " card principle, without separate " credit " and " debit " sides, and giving the balance in hand after addition or subtraction from the previous total. The headings are given along the top of the page over vertical columns. No periodical " closings " are required and it is claimed that ledger-keeping is much simplified thereby.

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New Army Manuals are also explained and reasons are given for dividing them up under technical headings instead of into manuals for the different arms. The different manuals deal with training, equipment, technical stores, supply, repair, ammunition, and musketry and have their distinctive colouring. Private enterprise is to be left a free hand in the provision of small handbooks for each arm. A multitude of such books of semi-official nature had appeared in Germany before the war, and it is considered that they do good service if they are not used merely as a short cut for the mentally indolent. The preparation of these manuals has been a matter of great difficulty, much of which is attributed to the inter-Allied Military Commission of Control.

Major Klingbeil—evidently an engineer of varied experience in fortification, for his name is becoming associated with different aspects of the question—contributes an article on reinforced concrete in permanent and semi-permanent fortification.

After a short historical *résumé*, he concludes that concrete (not reinforced) is unsatisfactory, because of its tendency to break and disintegrate, mainly on account of the shattering effect of a shell bursting after partial penetration. Large masses of concrete are naturally built up in sections and weakness follows between layers.

The use of reinforced concrete is dealt with historically, beginning with the patents of a resourceful Parisian market-gardener. Major Klingbeil is an enthusiastic advocate of the tensile strength and impenetrability of reinforced concrete, and he attributes the fall of the Belgian Forts (so constructed) to errors of design and execution.

For example, he states that a heavy howitzer shell entering a lightly-protected cistern penetrated an equally inefficient retaining wall and exploded in the main shelter of a fort, killing all therein. This shelter was itself sufficiently protected against a direct hit. His criticism of the Belgian fortresses of Liége, Antwerp and Namur is extended to the inadequacy of covering fire arranged over the gaps between the forts, and the editor is thus enabled to remark, in a footnote, on the illegal action of Belgian civilians in joining in the defence of these gaps against a " Völkerrechtlich ? " invasion.

Major von Kretzschmann continues his article on the tactical use of railways on the western front. His information is drawn in the main from articles which appeared in the *Verkehrstechnische Woche* from the pen of Professor Blum. The relative advantages of 60 cm. and 1-metre gauges are discussed historically, but there is nothing either informative or peculiarly interesting to note.

Lieut. Balck has interesting opinions to offer on infantry armament. He gives in detail the various weapons carried at the close of the war, and comes to the following conclusions :—The rifle should be an automatic loader, of smaller calibre than their existing pattern, and capable of single or of automatic fire. It should be sighted from 75 metres to 800 metres and its use not contemplated beyond that range. A bayonet, to turn up and down (like an Italian Cavalry carbine pattern), a spade with a sharpened edge, and a light automatic pistol complete the author's idea of equipment for a hand-to-hand combat. The present pattern of light machine-gun he dislikes as too heavy, too intricate, and too flat

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in trajectory. He has distinct leanings towards the Lewis gun. As a light machine-gun can be of no anti-tank value, he desires a small calibre to match his ideal rifle, whilst he wants three anti-tank heavy rifles per platoon. The heavy machine-gun should not be included in the company, principally on the score of the ammunition supply difficulty. He would keep hand and rifle grenades, but scrap the heavy automatic and long pistols and the grenade thrower.

The editor states that he cannot go all the way with Lieut. Balck, especially in limiting the range of the rifle to 800 metres.

Capt. Berschmann discusses the relative merits of caterpillar and wheel for mechanicalized artillery. He is of opinion that caterpillar traction is too slow for divisional artillery and suitable only for super-heavies and for guns dedicated to the close support of infantry. The presence of the good and numerous roads in Germany no doubt influences his opinion—and he states that if it were not for the time necessary for fitting the wheels for cross-country work before leaving the roads, wheels are superior in most ways. He also discusses the question of guns carried in or mounted on motor-waggons or carriages, and condemns them as inferior in every respect to the motor limber principle.

Lieut.-General von Schwarte begins a description of the assault on Nowo Gieorgiewsk. He points out that the operation was undertaken with Ersatz-Landwehr and Landsturm battalions. The fortress itself was a modern and well-designed one and had been improved during the early war period. Modern and well-designed field fortification filled the intervals between forts and between the three definite defensive lines. The northern front was selected for the attack, but no advance was possible before the advance of the Gallwitz Army, on the left, gave room for the necessary deployment. The field artillery available was mainly armed with the old 9-cm. or with captured Russian guns, and the heavy artillery allotted consisted of 17 Batteries (11 heavy howitzer, 2 mortar, and 2 high-velocity). This included, however, five 40-cm. and nine 30·5 howitzers and one 15-cm. gun.

Position immediately facing the Russian front line was taken on the 8th of August. The attack began on the 13th. After two hours' ranging and registration, fire for effect was opened at 10 a.m. and three hours later the infantry advance began and was carried forward successfully, but with severe casualties, up to 1,000 yards from the outer range of forts. On the 14th, fire on the forts themselves was opened, and good observation from balloons contributed to its success. The German flying corps brought intelligence of three lines of obstacles, continuous along the whole front—and here the story breaks off temporarily.

The concluding articles of both numbers are the beginnings of the history of a "*Vermessungs-Abteilung*," or field Survey Company, on the Russian and Roumanian fronts. The author seems to have had much to do and little to do it with.

He mentions his joy at finding printing machinery in Warsaw and, on appropriating it for the cause, does not seem to have invoked the severe rebukes which some of us incurred under similar circumstances.

It appears that transport was wholly lacking at first, and, of course,

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it soon became apparent that a mapping unit was of little value if it could not get there to map.

The interesting point of the articles is the mention of the transport of maps to the Roumanian Front by aeroplane from Vienna.

H.St.J.L.W.

BULLETIN BELGE DES SCIENCES MILITAIRES.

(*Nos. 5 to 7 of 1923 inclusive.*)

THE account of the operations of the Belgian Army during the Great War, 1914–18, is continued in Nos. 5 and 7 of the issue for the current year. In response to the urgent representations of King Albert and his Ministers for assistance, the Marine Brigade, R.N.D., which had been landed at Dunkirk on September 20th, was the first of the British reinforcements to be sent into Antwerp; on arrival there on the evening of October 3rd it was at once attached to the Belgian 5th Division. The Brigade was ordered to push forward to the neighbourhood of Lierre and to take over the trenches held by the 1st Brigade Mixte on the Nethe. Although the Belgian High Command was glad to utilize the Marine Brigade for the purpose of reinforcing the Sector of the Antwerp defences which was weakest, the *Conseil de Défense Nationale* was too fully cognizant of the true position of affairs to be deceived into thinking that the small addition of 2016 rifles and 12 machine-guns to the Belgian garrison could materially delay the advance of the Germans then attacking the southern Sectors of the *place forte*; particularly in view of the fact that the enemy was being continually reinforced by fresh troops from Germany. The presence of even a handful of British troops no doubt had an important moral effect; at the same time, there is no disguising the fact that the arrival of the British Marines in Antwerp caused a little embarrassment to King Albert and his Staff, tending, as it did, to interfere at a late hour with their plans. The King had two contending factions to deal with; those who favoured an immediate evacuation of Antwerp and those who held firmly to the tradition that the continued existence of the Kingdom of Belgium was indissolubly tied up with the fate of the famous Belgian citadel, and therefore urged that a final stand should be made by the whole Belgian Army along the ramparts of the old city on the Scheldt. The Germans apparently expected that this age-long tradition would definitely determine the course of events, and that they would thus be able to entrap the whole of the Belgian forces. A surprise was, however, in store for them. The views of King Albert were perfectly sound, and he intended that the Belgian Field Army should not tarry too long in the vicinity of the fortress, and took measures which, while they enabled the Field Army to put up a vigorous defence under the guns of the detached forts, at the same time secured the withdrawal of the mobile divisions sufficiently early to ensure that they should join up with the Franco-British forces which were racing to reach the Belgian coast. Fortunately, the Belgian King did not allow himself to be turned from carrying out his own plans by the various promises made to him that reinforcements would be sent to succour the Belgian Army. Attention is called in the original article

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to the fact that a large number of Territorial Divisions, which could safely have been utilized for a defensive war in Belgium, were timorously retained in the British Isles. On the other hand, the Germans boldly took risks and began almost at once to weaken their forces in Alsace and Lorraine with a view to reaching the Belgian coast quickly, in connection with their great outflanking movement (" the race for the sea "), and, having better railway communications at their disposal than those available to the Entente Powers in the coastal regions of France and Belgium, nearly succeeded in their purpose. The exhibition of equal courage in the matter of the transfer of the British Territorial Divisions to Belgium could not but have proved most advantageous to the Entente armies, and, *prima facie*, there seems to be some justification for the view that the British Government failed to show sufficient enterprise in connection with the utilization, at this juncture, of its second-line troops.

Questions affecting the rôle of artillery in a modern war are dealt with in Nos. 5 and 6 of the *Bulletin*. In the article in No. 5, Colonel A. E. P. M. Nuyten analyses and examines the experiences of the Great War in relation to the employment of artillery. The pre-war formula, he points out, postulated that " artillery no longer prepares attacks, it supports them." The practice in the Great War did not conform with the theory embodied in the foregoing formula ; on the contrary, it was conclusively proved that " artillery, *under centralized control*, must, in the offensive, undertake to facilitate and protect, by indirect action, *the attacks of the infantry* ; it must, at the same time, *prepare these attacks*, and, in particularly difficult circumstances, when called upon, the artillery must, so far as it is possible to do so, open the way for the infantry advance." Recent regulations on the employment of artillery issued in France and Germany are discussed in the original article, which will well repay any time spent on the study of its contents. The article in No. 6 of the *Bulletin* is from the pen of General Hellebaut, who writes to clear up certain points in relation to his article on " The Rôle of a Division in War," which appeared in the number of the *Bulletin* for July, 1922. The General favours the employment of artillery in mass and, to some extent disagrees with the views of certain junior artillery officers who advocate the employment of group formations of artillery acting in close *liaison* with the infantry.

The question : " Is Cavalry necessary ? " is discussed in Nos. 5 to 7 of the issue for the current year. The author of the original articles, Major A. E. M. Peteau, sets out to confute the suggestion that the cavalry failed in its rôle in the Great War. Cavalry enthusiasts had, in the years preceding the Great Conflict of 1914–18, built up a theory that a modern war would open with great combats *à l'arme blanche* between large cavalry masses, combats which would quickly determine the whole future of a campaign and at once decide as to the side to which victory would ultimately fall. There was, needless to say, nothing recorded in military history to justify conclusions of the kind alluded to. Disappointment has undoubtedly been occasioned in some quarters that the cavalry did not play the part predicted for it by theorists, and it would seem that irritation exists by reason of the fact that it was the voices of false prophets that made themselves most

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loudly heard on the subject of the rôle of cavalry in a modern war. Other false prophets there are now who, since the conclusion of the Great War, have been proclaiming that, in view of the trend of modern inventions, which enable an army to utilize aeroplanes, wireless telegraphy, armoured cars, tanks, motor-buses, cycles, railways, etc., for its own purposes on a very considerable scale, the cavalry arm has become redundant and should be suppressed. Major Peteau cites many instances in which cavalry played its distinctive rôle, and did useful and valuable work in Belgium, France, Italy, Macedonia and Palestine, and puts forward a very able argument for the retention of cavalry as an arm, although he is not prepared always to concede to the *new mechanisms* their true and proper value. The actual position of affairs is, of course, that many of the duties falling to the lot of the cavalry soldier can now be more rapidly and efficiently carried out by a skilful use of the new machine-equipped arms, and to this extent cavalry does not now occupy in an army a position of the same importance that it did half a century ago, but this, relatively, is also true in the case of the infantry. As in the ordinary business affairs of the world, so also is it in the case of armies, the technically trained man and his appliances are by degrees acquiring a dominant position in the situation; in the one case, in connection with the winning of supremacy in industry and commerce, and, in the other, in connection with the winning of victory in a conflict of arms. This does not, however, mean that an army can do without cavalry altogether, any more than that it can do without infantry; the situation is to be met rather by reconsidering what is the rôle that each of the older arms can most effectively play in the battle zone in combination with the *new mechanisms*, which are in no way rivals, but rather friendly companions of cavalry and infantry, and can, by complementary action, add enormously to the chances of obtaining success in a common cause, much in the same way that the older technical arms have, since their existence, augmented the offensive and defensive power of an army. Major Peteau examines closely into the causes of the failure of the cavalry to fulfil expectations and deals comprehensively with the present-day rôle of cavalry.

Capt.-Commandant A. E. M. Rootsaert contributes an article on Bridging to No. 5 of the *Bulletin*; it is based on contributions on the subject contained in various numbers of this Journal, the British official publication, *Bridging—Provisional*, 1921, the American *Military Engineer* (Sept.–Oct., 1921) and the *Revue du Génie* (March, 1923). A brief description is given of the British bridging equipment and attention is called to certain experiments carried out in the U.S.A. with a view to testing out the relative merits of aluminium, steel and wood as materials for the construction of pontoons. The results of the experiments are tabulated under fifteen heads, *e.g.*, weight, buoyancy, maintenance, cost, etc.; aluminium and wood possess the maximum of advantages and disadvantages.

Very little information has been published, except in Germany, as to the part played by Russia in the Great War. General J. Daniloff, who was Deputy Chief of the Russian General Staff for the five years preceding the outbreak of war, and later held important positions in the

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field, contributes an interesting article to No. 6 of the *Bulletin* (accompanied by three sketch maps) dealing with the strategic deployment of the Russian Army and its initial operations. Owing to the alliance entered into between France and Russia in 1899, the officers of the General Staffs of the two armies met periodically to discuss the proposed plan of operations in the event of a European War and to amend it as required, owing to changes in the strategical situation. General Daniloff points out that the coolness which arose in 1906–1907 between Italy and the Central Powers was all to the advantage of France; on the other hand, with the progress of time, so far as Russia was concerned, the situation, for various reasons, became more and more complex. The General recognizes that, theoretically, the western salient of the Polish frontier was strategically advantageous to Russia, but, he points out, it was not possible to obtain the full benefit of this geographical configuration; first, because the mobilization of the Russian Army could not be effected as rapidly as that of the German and Austro-Hungarian Armies, and secondly, because the possibility, remote though it was, existed that Germany might attempt first to crush Russia before throwing her main weight against France. In such an event it was probable that, while Austro-Hungarian forces struck from Galicia in the direction of Brest Litovsk, German forces would simultaneously advance from East Prussia in the direction of Bielostock. It was felt by the Russian General Staff that in the event of a double offensive launched from Galicia and East Prussia, immediately on the declaration of war, a Russian force in the Polish salient would be placed in a perilous position during the initial stages of its mobilization and concentration. Consequently, it was, in 1910, decided to withdraw the part of the Russian Army stationed in peace time in the Polish salient to a line further to the east: the adoption of this course had the effect of leaving the Russian fortresses on the middle Vistula, the Bug and the Narew "in the air," and led to the situation being closely reviewed. It was fully recognized by the Russian General Staff that, in view of the proximity of certain important centres of German industry to the French frontier and the fact that France would be ready to strike earlier than Russia, and almost as soon as Germany, it was highly probable that the Kaiser's main armies would, in the first instance, concentrate against their western foe. The Teuton General Staff, needless to say, took measures with a view to keeping Russia in ignorance and in doubt as to the course intended to be adopted; however, the steps taken in connection with the strengthening of Germany's western defences and the railway developments on her western borders did not pass unnoticed in Russia, and fairly correct conclusions were reached by the Russian General Staff regarding the German plan of campaign, as it actually was opened. The French General Staff was naturally desirous that offensives should be launched simultaneously from the West and the East against Germany, but this was out of the question, and the Russian General Staff made it quite clear to their Allies that the Russian Army could not possibly undertake any offensive operations until the 15th day of its mobilization. Before the outbreak of the war, Russia possessed 37 Army Corps, but of these it was expected that 28 alone could be

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concentrated on the Western frontiers of Russia within the first three or four weeks from the date upon which orders to mobilize were given. The nine remaining Corps were, in peace-time, stationed in Siberia, Turkestan and Transcaucasia, and it was not likely that they could be available for operations against Germany and Austro-Hungary under a couple of months. In preparing her plan of campaign, Russia had not alone to concentrate her attention on Germany and Austro-Hungary, but she was obliged to take into account (i) the possibility of having to meet a Swedish attack in Finland; (ii) the probability of Turkey espousing the cause of the Central Powers, either on the outbreak of war or almost immediately thereafter; and (iii) the uncertainty as to the side with which Roumania would throw in her lot—at one time the Roumanians were distinctly hostile to Russia. Further, so far as Germany was concerned, there was always the possibility that, in addition to an advance on land in East Prussia, the German General Staff would take advantage of the superiority of the German Navy over the Russian Navy in the Baltic to effect the landing of a German force on the shores of Russia's Baltic Provinces. To meet the foregoing situation, the Russian 6th Army was, in the first instance, placed in observation of Sweden and the Baltic shores, while the Russian 7th Army took up a position in the South to keep a watch on Roumania and the shores of the Black Sea. For the main operations against Austro-Hungary and Germany two independent commands were formed, namely, that on the "South-Western front" which was given to General Ivanoff, and that on the "North-Western front" under General Gilinsky. General Ivanoff had two groups of Armies under him; one, consisting of the 4th and 5th Armies (seven Corps), was formed up south of the line Lublin–Kholm, while the other, consisting of the 3rd and 8th Armies (nine Corps), took up their initial position on the line Rovno–Proskurof. The objective assigned to General Ivanoff's Armies was to defeat the Austro-Hungarian Armies deploying in Galicia and to seize the mountain passes giving access to the plains of Hungary. The main attack was to be delivered by the 3rd and 8th Armies, and, in consequence, a special effort was made to get them ready to start operations at as early a date as possible. General Gilinsky had under his command the 1st Army (Rennekampf; eight Corps) and the 2nd Army (Samsonoff; five Corps); the 1st Army was deployed on the middle Niemen, while the 2nd Army took up a position along the Narew and Bobr. These two Armies had assigned to them the common objective of defeating the German forces in East Prussia. The 1st Army was to advance to the north of the Masurian Lakes, while the 2nd Army was to invade East Prussia from a line permitting it to advance in a north-westerly direction, so as to leave the Lake District on its right flank. Of Russia's 28 Army Corps mobilized on her western frontier, 20 were initially placed north of the Pripet and 8 only (3rd and 8th Armies) were south of this river.

When war was declared, the intelligence received at the Russian G.H.Q. indicated that the German II Corps (Stettin), the V Corps (Posen) and the VI Corps (Breslau) were proceeding westward by train, and it was accordingly assumed that the Germans did not intend to effect a landing on Russia's Baltic coast line; it was further ascertained that, in addition

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to these three German Army Corps, Russia would initially only have certain reserve, landwehr and formations to deal with. This intelligence led to certain modifications being made in connection with the dispositions of the troops told off for observation purposes, and a 9th Army was formed; it was concentrated near Warsaw and, southward of its position, a strong bridge-head was hastily constructed on the left bank of the Vistula covering Ivangorod. Among the tasks allotted to the 9th Army was that of securing the routes leading to the Vistula, on the front Cracow–Posen. On the eighteenth day of the Russian mobilization (August 17th), the main body of the Russian 1st Army crossed into East Prussia and three days later advanced troops of the Russian 3rd and 8th Armies entered Austria-Hungary.

W.A.J.O'M.

THE MILITARY ENGINEER.

The Military Engineer, published bi-monthly in Washington, is the Journal of the Society of American Military Engineers. Price 75 cents per copy.

Attractively produced and well illustrated, it contains, in addition to military matter, many items of general engineering interest and evidently enjoys a considerable circulation.

Its list of advertisers numbers over two hundred, and includes some of the leading engineering and contracting firms in the country.

In the May—June, 1923, number, Colonel B. O. Johnson, formerly of the Russian Railway Service Corps, contributes an account of the exploits of a party of American engineers who, in April, 1918, were sent to assist in the reorganization of the Trans-Siberian Railway. Their experiences under Soviet régime and their handling of 300,000 German and Austrian prisoners of war, who seized rolling stock and started a repatriation movement of their own, are well worth reading.

"Flood Control," "The Destructive Effect of Marine Borers," and "The Revetment of River Banks with Reinforced Concrete Mats," contain up-to-date matter on subjects which directly concern American Military Engineers.

"The War-Time Control of Industry" has recently received much attention. Two further articles are included in this issue.

Under the heading of "Psycho-Physiology and Military Training," Captain Gillette, Corps of Engineers, favourably contrasts the British system of elementary training with that in force in the American Army.

Other articles include "Air Service and the Corps of Engineers," "Preparation and Distribution of Maps," and "The Crossing of the James River, in 1864."

Space is allotted to news of the Society of American Military Engineers, the National Guard, The Organized Reserves, and to the usual Correspondence.

July—August.—"The Service of Military Roads in France," by Lt.-Col. Durham, describes the French national highway system and the methods of co-ordination adopted by the various Allied road services. Washington prepared an elaborate road scheme for the A.E.F., but,

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as a result of the military situation on its arrival, the bulk of the personnel was drafted into fighting units. The Force made good its road damage, estimated at 1,000,000 cubic metres, before leaving.

Major Kirby contributes a second article on "Army Map Reproduction in France." In addition to its base reproduction plant at Langres, the A.E.F. assembled mobile topographical trains, a section consisting of four lorries, carrying one large rotary lithographic press with accessory plant. These sections proved very useful in following up the advance, and were loaned to the French and British. A complete train of forty lorries was tried after the Armistice with equal success. This is still in use with the Eighth Corps at Texas.

Maj.-Gen. Farnsworth, Chief of Infantry, outlines the characteristics of modern infantry, with special reference to the co-operation of Engineers.

Other items include a description of the American tanks, a design for a temporary suspension bridge, and a study of tidal action on coasts and in estuaries.

Correspondence indicates that pacifism is still proving an obstacle to recruiting.

R.I.M.

REVUE MILITAIRE GÉNÉRALE.

(*March*, 1923.)—*The Army General Organization Bill.* By Lieut.-Colonel de Thomasson.—The bases of military organization in France are the three Acts regulating recruiting, general organization, and cadres and effectives. The first has recently been passed, after many delays; the second, the subject of this Article, has only just been finally drafted, so that the Chamber has been compelled to abrogate part of its functions, and to give the War Ministry *carte blanche* to put the principles of the Bill into practice before it has been passed. In bringing the Recruiting Bill before the Senate, General Bourgeois showed that from 1872 to 1914 the army in peace was the framework of the army in war, and, leaving aside the territorial, the latter was completed by the incorporation of reservists. As to mobilization of the resources of the nation, all that was expected was certain supplies, of which the late war evinced the insufficiency, at the same time making such heavy demands on the man-power of the nation as almost to paralyse its life. To-day, instead of mobilizing the whole army at once, the principle is introduced of first rapidly mobilizing the covering troops up to a fixed establishment, and then, by means of mobilizing nuclei left behind by them, of raising and grouping new units to form the national army. But as the whole organization is not required to function at once, the size of the nucleus can decrease in proportion as the length of time increases within which the new unit is required. The peace establishment is therefore governed by consideration of the numbers required for covering duties, for the mobilization centres, for producing the necessary numbers of reservists and for instruction and ordinary peace duties.

Admitting the above principles, the new Bill must clearly differentiate between the peace establishment and the mobilizing units. The former

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must, for many reasons, be a variable quantity, while the latter must form a network so fine that no resources utilizable in war-time can escape its meshes. The highest military authorities have now agreed with the Army Commission of the Chamber that the peace establishment shall be 32 divisions of three regiments each. The division, equipped with the most recent armament, is adopted as the battle unit, the late war having demonstrated that it is the real permanent unit, the army corps consisting of a variable number of divisions. Besides the divisions, troops which cannot be permanently incorporated in them, such as machine-gun battalions, tanks, heavy artillery, aeroplanes and cavalry, must be provided as a general reserve in the hands of the higher commands. Their numbers and composition will appear in the Cadres and Effectives Bill.

The commands of the mobilization regions will be quite distinct from those of the army, and, as mobilization of all the resources of the nation is intended, will include representatives of the civil services, public works, mines, forests, manufactures, and hydraulic and electrical enterprises. A proposal to place a civil administrator at the head of each region has not found favour, owing to the multitude of purely military duties involved. The number of regions has been fixed at 20, which, oddly enough, roughly coincide with the old French provinces. The subdivisions, which have stood the test of 50 years, will remain exactly the same. *Liaison* between the regional and troop commands is ensured, for the time being, in that the latter are responsible for training and in most cases supply the personnel for the mobilization centres. Later on, centres may be established which will be independent of the troops and more schools of instruction will be set up. To ensure this *liaison*, a higher command over both troops and regions is instituted, corresponding to the army corps command. In view of their responsibility for organizing the whole country, the latter will be in communication not only with the Minister for War, but with the ministers of all the services affected. The number of army corps commands has been fixed at 16 for the present, *i.e.*, the number required to be functioning on mobilization.

A map is attached showing the boundaries of the regions and the distribution of 26 divisions, the six remaining divisions forming the Army of the Rhine. In each region is stationed a white division. In the five frontier and one other region there are also mixed divisions, each consisting of one white and two native regiments. The 16 army corps will be three on the Rhine, and 13 in the interior. Five corps commanders will each command a frontier region and two divisions, one white and one mixed. One will command the military government of Paris with one white division. One will command two regions and three divisions, two white and one mixed. Six will each command two regions and two white divisions. The organization of the colonial forces is hardly touched upon in this Bill, as it presents difficulties which must be dealt with in the Cadres and Effectives Bill.

It has been objected to this Bill that, in arranging for progressive mobilization, a prolonged war is pre-supposed, but there is nothing to prevent war from being prosecuted vigorously from the very beginning,

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assuming that the probable enemy is Germany. The covering troops could be quickly moved into the enemy's territory and his mobilization interfered with, seeing that it must take place in the region of the Elbe, whilst that of the French would proceed in full security. But even this latter, and the inviolability of the French frontier are not absolute certainties, owing to want of knowledge in regard to the future development of aviation and chemical warfare, but no system of organization can ward off these dangers. If Paris can be destroyed in a few hours, the best defence is to be in a position to destroy Berlin in a still shorter time. The constant care of the French Government must be to assure the army mastery in the air on the outbreak of war, and to this end aeronautics must be kept fully equal to this task in times of peace.

Another objection is that raised by the partisans of mechanism and material in place of men, but even machines require men to work them. The total man-power must be the same, but its centre of gravity is displaced further to the rear, and as an extreme case it is pointed out that a chasing aeroplane carries only one or two men, while about forty are required for it between the aerodrome and repair park. In the writer's opinion the gravest objection is that the second line to follow the covering troops is to be mobilized on the outbreak of war from the resources provided by *disponibilité* and the active reserve, *i.e.*, in each unit there will be men of different ages, and such bodies cannot be equal in quality to the peace army. After all, values are relative and the 32 first-line divisions will be as much superior to the Reichswehr units as the French effectives of 1914 were to the Imperial Army and, should hostilities be prolonged, there is no doubt that the second line will be fully equal to the tasks assigned to it. The great point is to see that there is a good framework for the second-line troops, and this affords the strongest argument for raising the professional army of 100,000, provided for in the Recruiting Act, but which is far from being realized at present.

It is regretted that the drafters of the Bill have stopped short at the army corps, and have not proceeded further to lay down army districts commanded by those who will exercise the army commands in war, and who, in peace, should be stationed in the provinces with the formations which will come under their orders. It would cause no further expense, as the staffs are retained as *Inspectorates* in Paris, and it would admit of decentralization of command and administration and relieve the War Ministry of a heavy burden. The Minister for War would then have only four or five immediate subordinates, instead of some fifteen, and a great source of friction and delay would be removed. Promotion in all grades should be carried out inside each army, which would be large enough to make advancement fair to all, and small enough to allow of a personal interest in candidates. A right of appeal to the War Minister, as constitutional head of the army, must be reserved.

Our Marshals of France.—A lecture delivered at the Grand Chancery of the Legion of Honour on 30th June, 1922, by Capt. René Audriot, consisting of a series of anecdotes of former marshals of France, told in a chatty manner, and in no regular historical order. Should be read in the original. In the days of the first two French dynasties the *marishalk*,

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or, in Low Latin, *marescalcus* or *marescallus regis Franciæ*, was merely a sort of head groom, or esquire of the stables. By degrees his duties acquired a military character, and under the Capets he became Chief of the Horse, but in time of war only, and the great feudal lords entertained similar retainers. As the king's authority increased, his marshal acquired greater prestige, and ultimately became Marshal of France, since when his authority and eminence have been continually augmented. After the war of 1870 the appointment lapsed; the last existing, Canrobert, appointed under the Second Empire, died in 1894, and it was not until 1916 that the office was re-established by the appointment of Joffre for his services in 1914.

The Rhine Advanced Guard. By Commandant A.G.—The object of this article is to study the conditions which may obtain in case of a further conflict between France and Germany, assuming that France will be, as now, in occupation of the Rhine provinces. While after 1870 Germany held the whole left bank of the Rhine and Alsace-Lorraine, where she collected a mass of warlike material enabling her to strike a stunning blow in the direction of Paris, she has now been thrown back across the Rhine, and is so threatened by the French Army of Occupation that she must withdraw further east her base of concentration, probably to the Weser. In place of 25 well-equipped army corps, capable of duplication by almost equally valuable reservists, Germany now only possesses an army of seven divisions of infantry and three of cavalry, for, although she has more or less disguised auxiliary formations, such as Sicherheitspolizei, Schutzpolizei, etc., they are unprovided with artillery, unless any important quantity of the latter has escaped the attentions of the Inter-allied Commission. Two arms, however, of which she will make use are aviation and toxic gases.

On the other hand, France now occupies the Rhine Provinces with bridgeheads on the river, where she has an army of occupation fully mobilized and ready to move at once into hostile territory. Behind this force four army corps on the frontier could be moved forward in a few days, and the main portion of her forces could follow in three or four weeks, fully staffed and equipped. The Belgian Army would also be ready to co-operate. It is evident that France, at the outset, would have the advantage in men and materials, but this would gradually decrease as Germany produced her new formations and plant, until, in the end, the superiority would pass to the latter, owing to her larger population, and better developed industries.

It may be expected that Germany has some plan for quickly increasing her armed forces, say, that each battalion becomes a regiment, which would triplicate her strength to 21 divisions of infantry and 9 of cavalry, with an unknown number of auxiliary formations, the latter with few or no guns. The time necessary for mobilization and concentration can only be guessed, and may be assumed at five or six days for the former and six or eight more for the latter. Parallel with this mobilization an air force will be organized, for, although aviation as an arm has disappeared (Treaty of Versailles, Art. 198) plans for its employment have been stubbornly pursued, and are not likely to be left in the experimental stage by Germany, and the treaty may be modified on

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this, as it has already been on so many other points. Fleets are likely to replace squadrons, and it may reasonably be expected that the Germans will strive to shatter French morale by bombarding the large towns and industrial centres. Again, the use of gas, although forbidden by the Versailles Treaty, is certainly being prepared for by Germany—witness the accident at Ludwigshaven in September, 1920. New gases may be discovered and rapidly produced from the huge plants existing in Germany. Tanks may be improvised from agricultural tractors.

Covered by this first line, Germany would proceed with the general mobilization of the country in order to raise a national army. In estimating the time required for producing the material for this army, assume that all warlike stores unauthorized by the Treaty have been handed in, and that all new manufacture has ceased; but preparation for manufacture cannot be prevented, and construction might even be clandestinely commenced somewhat before the date fixed for opening hostilities. Experience gained in the late war has shown that material for war, all details having previously been arranged, takes five or six months to manufacture, or, deducting the time during which manufacture may have been secretly going on, say, three or four months. The problem for the German High Command is, then, to determine how best to employ their covering troops on the ground they will have available to manœuvre over, should the French decide to cross the Rhine after their concentration is completed. The latter could not advance beyond the river with all their forces united in less than three or four weeks, and in this period the German covering troops would be organized in their positions and ready to fight. Carefully thought-out plans for holding the zone between the Rhine and the Weser would include numerous demolitions, the denial of certain tracts by inundations or gas, the preparation of successive positions, and experience has shown that an advance through such country resolutely held by thoroughly trained troops, even if relatively small in number, is a tedious matter, and might even result in giving Germany the breathing-space she requires.

In view of the above possibilities it is a great question whether it would not be better for the French to take advantage of their peace-time superiority of force, and at once to advance boldly into the territory the Germans hope to reserve to themselves for manœuvre, more especially having regard to the damage German aeroplanes may be causing during the delay. Such an advance would compel the Germans to retire the concentration of their covering troops further east, would deprive them of the advantage of the barrier of the Rhine and of a portion of the ground they require for defence, and would check the activities of their air force by fear of reprisals on such towns as Frankfort and Essen. It would not do to advance at once for 150 or 200 km. to avoid the risk of a German counter-offensive in considerable force, but to lay hands on the Ruhr basin and Frankfort (first phase), and advance the concentration of the main army close to the Rhine, say, between the Maine and Ruhr (second phase). The first even might have the effect of incapacitating Germany for further operations.

It may be objected that this plan violates the principle of strategy which enjoins concentration of force at the decisive point, and avoidance

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of division of force and engaging in detail, but that refers to a battle against the main enemy forces. The assumptions on which this study is based show the conditions to be quite different. It has been estimated that the Germans will require about a fortnight to mobilize and concentrate their covering troops, and, adding two or three days' marching to reach the French assemblies, there can be no question of battle before the eighteenth day. The French advanced troops, assumed as ready to proceed before the end of the first week, will only have to surmount detached bodies and, later on, destroyed communications. Having reached their objectives and been reinforced about the fifteenth day by the frontier corps, they will have acquired the strength of an army group and be capable of any action required. The troops available will be the French and Belgian armies of the Rhine with several cavalry divisions ready on the fourth or fifth day, and the four frontier corps ready to follow in a few days. About the fifteenth day eight or nine army corps would be on the selected covering position, assuring the detrainment of the main army on the Rhine, and by the middle of the third week, before which it has been shown that the Germans could not attack, part of the corps from the interior will have detrained and be in a position to intervene. Again, it is hardly likely that the Germans, whose main object is to gain time, would adopt an offensive attitude which would in the end bring them up against the main French armies. The risks are, therefore, slight and the advantages considerable, whether from the strategic or political point of view, and might even nip the German mobilization in the bud.

Remarks on the material required follow. All wheeled vehicles must be replaced by those moving on tracks, and the steering and pace of these must be improved. Tanks should be capable of speeds up to 25 km. per hour, should carry crews of at least three, and be fitted with an apparatus to enable the commander to see as well as if he were in the open air. Thus powerfully equipped, with guns and supply vehicles, the advanced troops, soon to be reinforced by a second echelon, should rapidly overcome the weak German covering force, and enable the main scheme of operation to be realized, that is, to carry the war as soon as possible into the base of concentration of the German national army.

Records of Foreign Armies.—Major de Vallière contributes a short description of the Swiss cavalry. The Czecho-Slovak budget for national defence is analysed, and some information afforded in regard to the methods adopted for providing and training officers for the active and reserve formations.

Bibliography.—The following books are favourably reviewed :—

Essai sur la fortification permanente moderne, by Colonel Levêque (Berger-Levrault) which is said to afford a sound foundation for anyone who wishes to commence a course of study of permanent fortification adapted to modern conditions.

Ou va le monde? Considérations philosophiques sur l'organisation sociale de demain, by Walther Rathenau ; French translation by S. Sankélévitch (Payot).—The ideas expressed in this book found no favour in Germany, and excited such dislike that the author, who hoped, as a

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Minister, to make them the foundation of his activities, was assassinated. They are, however, based on sound reflection on subjects which canno be neglected at the present day.

Les lois éternelles de la guerre (Berger-Levrault), by General Arthur Boucher.—Struck by the fact that the small Greek nation not only successfully opposed, but ultimately conquered the much larger Persian nation, the author has drawn the conclusion that even at that remote period the art of war had reached a degree of perfection hard to surpass. To compare the methods, and show that the principles which then held were still applied twenty-three centuries later, is the object of this interesting work. A second volume is expected which will deal with the art of war in the 1914–18 campaign.

(*April*, 1923.) *The Rupture of the Bulgarian Front at Dobro-Pole.* By Commandant Paul Casson, from documents supplied by Lieut.-Colonel Theodoroff of the Bulgarian General Staff.—When the Great War began Bulgaria saw a chance of reversing the injustice done to her by the Treaty of Bucharest, and of recovering Macedonia and the Dobrudja which she had won at the cost of so much sacrifice. In November, 1915, the Serbian Army had been defeated, but not entirely destroyed, when Mackensen's Staff decided that sufficient had been done to serve Germany's purpose, and gradually withdrew from the Southern front all but three German divisions. Operations were left to the Bulgarians with slight assistance from Austria and Germany, and the Serbian Army was driven out of the country. The Bulgarian Army was then reduced to inactivity on the Greek frontier, to serve Germany's political ends, of preserving Greek neutrality and of retaining a portion of the Entente forces at Salonica, in spite of Bulgaria's protests that the Expeditionary Forces should be driven from Macedonia and not left at liberty to reorganize the Serbian Army and ultimately to be in a position to invade Bulgaria. The period of inactivity was marked by a gradual deterioration of the morale of the Bulgarian Army, owing to difficulties of supply, due to the mountainous country and lack of roads and railways, to defeatist propaganda, to the unfavourable decision regarding the Dobrudja, to the alteration of the Eastern frontier in favour of Turkey, and to the exhaustion of the country by Germany's requisitions of foodstuffs. In 1918 desertions were frequent and mutinies broke out, while the supply arrangements grew worse, many soldiers were in rags and barefooted, food had to be rationed, and many horses died of hunger or had to be sent to the rear, or even back into the interior, to be fed at all. Another source of weakness was that the Bulgarian forces were staffed by Germans, who, although efficient in military matters, altogether failed to realize the Bulgarian point of view and difficulties, refused to appreciate the actual situation, and worked on their pre-conceived idea that the war on the Southern front must be prolonged, while denying Bulgaria the assistance she demanded.

From the foregoing the state of the Army in September, 1918, may be imagined. It was condemned to a passive, even though it might be a stubborn, resistance, and all initiative was abandoned to the enemy. The impending attack was foreseen by Bulgarian Headquarters in June, and attempts were made to form reserves for the threatened sector.

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It was known that British troops in the Struma sector had been replaced by Greeks, and sent to the Vardar to relieve French troops required to form a striking force, and by August it appeared certain that the Allied offensive would take place in the mountainous region of the Moglena, yet the Germans were still removing their troops from Macedonia to the Western front. Early in September the Bulgarians held the whole line of 573 km., from Albania to the mouth of the Maritza, joining hands with the Turks to the East and Austro-Hungarians to the West. The troops in line consisted of the 11th, 1st, 2nd and 4th Armies with, of Germans, 3 battalions, 40 batteries, 4 squadrons, and 342 machine-guns divided between the 11th and 1st Armies. The sector attacked was held by the 2nd and 3rd divisions, both belonging to the 11th Army, but, although the broken ground was favourable for defence, this did not compensate for inferiority of numbers. The 2nd division held a front of 17 km. with 18 battalions and 86 guns, the 3rd a front of 40 km. with 21 battalions and 66 guns, an average of 1½ km. per battalion. In reserve the 2nd division had 7 battalions two to eight hours' march to the rear, the 3rd division one battalion close to the line. The Army Corps Reserve was 3½ battalions, some two days' march to the rear, the Army Reserve, two German and three Bulgarian battalions, three or four marches off. The reserve of the Army Group was one German and five Bulgarian battalions with three batteries, two or three days' march away, and the General Headquarters Reserve seven battalions and nine batteries at four to eight days' distance by rail and road. These isolated battalions were not organized in brigades or divisions, they were destitute of transport, and in no way represented formations fitted for manœuvre.

It soon became evident to the Bulgarians that the main attack would be on the Dobro-Pole sector, with possibly a secondary attack up the Vardar Valley, and reinforcement of this front was demanded. The Germans held that the attack would be made on a much wider front, would be preceded by a long artillery bombardment so that surprise need not be feared and time would be afforded to bring up reserves, and that the reserves were sufficient to meet all eventualities. No representations of the Bulgarians could modify this attitude. At this time the German G.Q.G. sent a landwehr division to the Struma sector to spread defeatist propaganda among the Greeks. Every day groups of the latter with their officers deserted to the enemy, but the division would have been better employed if placed in reserve at Gradsko in the threatened sector. Bulgarian Headquarters cannot be absolved from blame for not pressing with greater vigour their own rights and the national interests.—(*To be continued.*)

How Remigenos Gabu, Prince of the Mirhattas, Studied the Arts of War. By Malo.—Describes how the Prince, after receiving his father's blessing and a sum of money, travelled in the neighbouring countries to study their methods of waging (or avoiding) war. Each had some sovereign specific, generally unpractical, on which it relied. On returning he found his father, the old king, on the point of death, having evolved a scheme of his own for ending war. This was to ensure that all men might have everything they require for their bodily needs. When this is

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the case a desire for ease, and affection for their fellow men, will remove every incentive for killing them. Written of medieval times, in somewhat medieval French, the article is not without a vein of humour, a somewhat bold innovation which the editor hopes may possibly be appreciated by readers of the *R.M.G.*

Strategy and Operations of the Allies in the North.—A continuation of the article by Capt. Kuntz.—The retreat of the French 5th Army on August 24th and 25th, 1914, is shortly described, also that of the British Army on the same dates, including the engagement at Landrecies on the night 25th/26th.

Bibliography.—The following are some of the books reviewed:

La Bataille de Montdidier. By Commandant Daille. (Berger-Levrault).—Describes the operations of the 1st French Army (General Debeney) which was placed under Field-Marshal Haig's orders for the battle of Amiens, 8th to 10th August, 1918. Ludendorff, in his *War Memories*, refers to the 8th August as "Germany's black-letter day."

L'Afrique Orientale Allemande, et la Guerre de 1914–1918. By Commandant Breveté J. Buhrer (Fournier), is said to be an excellent work.

(*May*, 1923.) *The Fatal Quarrel between a Chancellor and an Admiral.* By Capt. de Gaulle.—For two years there was strong antagonism between the government of Germany and the Navy; the decision reached in opposition to the advice of the man best placed to know all the issues involved, the head of the government, was the direct cause of the German defeat. If the government had been free to conduct the war according to accepted principles, Germany might have found a way out of her difficulties. Without the intervention of America and the hopes built upon it by the Entente, the Russian revolution and the moral consequences of the check to the French arms in 1917, combined with the efforts in London of Lansdowne and Ramsay Macdonald, would have placed the Empire in a favourable position to negotiate a peace with the aid of the mediation opportunely offered by President Wilson.

Until early in 1916 Grand Admiral von Tirpitz was Secretary of State for the Navy. Even before the war there had been bitter and continuous enmity between him, a Prussian Junker, and the Chancellor, Bethmann Hollweg, a lawyer and a democrat. While the former was virtual father of the German fleet, and the moving spirit in the struggle for supremacy in armaments directed against England, the latter had been desirous of an agreement with London, and had favoured Lord Haldane's visit to Berlin, and the limitation of naval construction. From the commencement of hostilities the Grand Admiral did not disguise his opposition to the war policy of the Chancellor. Bethmann hoped one day to reconcile Germany and England, and intended to make Russia pay for the war. Tirpitz dreamed of an understanding with the Czar and the overthrow of the democracies of the West, and had devoted his life to preparing for war with Great Britain.

Tirpitz, whose proper place was in Berlin, wished to accompany the great General Staff in hopes of making his influence felt in its deliberations, but was mistrusted by both the Emperor's cabinet and

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the army staff. He took his revenge in sarcastic references to the army, and definitely proposed that the fleet should take the first favourable opportunity to put to sea and seek an engagement, but this did not appeal to the Emperor, to the fleet, or to Falkenhayn, C.G.S. of the army. In the height of his bitterness he indulged in fierce denunciation of his personal enemy, the Chancellor, whom he accused of keeping the fleet inactive from fear of England.

On 4th September, 1914, the friends of v. Tirpitz made a diversion in his favour in the Reichstag by inviting the government to introduce a bill declaring the urgency of fresh naval construction, and Count Reventlow, his personal friend, commenced in the *Deutsche Tageszeitung* a campaign in the same sense. But before the battle of the Marne everyone expected an early termination of the war, while it would take three years to complete new battleships. The Chancellor obtained a vote against the proposal, and by so doing increased the resentment of v. Tirpitz. The latter thereupon decided, without any great enthusiasm, since he had always been an advocate of big ships, to support submarine warfare, but only on condition that it was conducted on a scale large enough to obtain a quick decision before the Entente could devise adequate means of defence, and neutrals, especially America, could define their attitudes, and perhaps prepare for intervention. This was not the opinion of v. Pohl, the C.G.S. of the Navy, a narrow-minded, vain and ambitious man, who, jealous of v. Tirpitz, was inclined on principle to oppose his recommendations. It appears, too, that v. Pohl owed his appointment to this well-known hostility, and to the hope of the Emperor's cabinet that he would tend to neutralize v. Tirpitz's activities. Von Pohl then decided at once to embark on the submarine war, the more so as he was about to take command of the fleet, and wished to sign the order for this novel method of warfare before he quitted the great General Staff.

With little grasp of the technicalities of naval warfare, Bethmann, at all events, realized that submarine attacks on merchant shipping would raise acute difficulties with foreign countries, and that the ruthless submarine warfare proposed by the Naval General Staff, which meant sinking ships without warning, and thus depriving passengers and crews of any chance of escape, would certainly lead to a difference of opinion with Wilson, and war with the United States. He was resolved to do all he could to prevent the latter joining the Entente, as, besides the moral and material support they would afford, he foresaw the ruin of his hopes of their mediation at some favourable moment. Once Tirpitz grasped the Chancellor's opposition to submarine warfare, he set to work to demand it with the same energy and tenacity with which he had hitherto condemned it. When at the end of December, 1914, v. Pohl proposed to declare a submarine blockade of the coasts of Great Britain and Ireland at the end of January, v. Tirpitz evinced his disapprobation of the date, which he considered premature, at the same time declaring his adherence to the principle. The Chancellor saw that the Emperor and G.Q.G., depressed by their recent check on the Yser, and the prospect of a winter of stabilization, were ready to listen to the restless protagonists of the Navy, who promised to bring England to

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her knees in six weeks, and to gain time approached v. Tirpitz, who wished to postpone the declaration of the blockade. At the end of January the latter agreed to oppose v. Pohl's precipitancy, and Bethmann set the Ministry of Foreign Affairs to work to draw up the text of the declaration of blockade. This would take some months, and by the spring great military events could not fail to arise and the Emperor would have something else to think of. But on 4th February the Emperor, without the Chancellor and Foreign Minister, paid a visit to Wilhelmshaven, and allowing his dormant maritime ambitions to be stirred by what he saw, signed a declaration of blockade drawn up by v. Pohl which the latter told him had previously received the assent of the Chancellor. Tirpitz was present and offered no opposition, confining himself to the modification of certain details. The only explanation of this change of front on his part is his hatred for Bethmann, and his desire to involve him in difficulties in the hopes that he might tender his resignation. The declaration was immediately published, and Bethmann accepted the *fait accompli*, not having the strength of character to oppose it openly. On 12th February the American protest against the declaration of the blockade arrived in Berlin, warning Germany that she would be held responsible for damage to life and property of United States citizens caused by submarines. On its receipt the Chancellor obtained from the Emperor an order to await further instructions before commencing operations, and, distrusting Tirpitz, and the new C.G.S. of the Navy, Bachmann, took the precaution of directing all submarine commanders to respect neutral ships in the blockaded area. He also induced the Emperor's cabinet to send a telegram to v. Tirpitz asking if he could guarantee bringing England to terms in six weeks by the war against her commerce. Although six weeks earlier Tirpitz had told Bethmann, and written to the Emperor, that in his opinion submarine warfare ought to be postponed owing to want of sufficient means to prosecute it thoroughly, he now, carried away by personal animosity, boldly replied that he and Bachmann were convinced that in six weeks from the commencement of the new submarine war England would be brought to terms. This promise prevailed with the Emperor's cabinet, and on 20th February orders were issued for the blockade. Once it was proclaimed Tirpitz and Bachmann set themselves to intensify it in spite of adjurations from the Wilhelmstrasse. They began by exempting commanders from the order to spare neutral vessels, on the pretext that all vessels of the Entente sailed under neutral flags. The free passage at first reserved for Swedish and Norwegian vessels was soon closed, and at length, on the plea that the safety of German crews outweighed all other considerations, ruthless submarine warfare was enjoined. It was in vain that the Chancellor counselled moderation in the light of foreign affairs. Italy was inclining towards war, and Bulgaria was offering her help. To calm the one and draw on the other it was necessary that the policy of the Central Powers should not be condemned by neutrals; but if Bethmann realized this he had not the power to order, nor the character to insist.

The *Lusitania*, filled with Americans, was sunk on 7th May. Wilson protested, and claimed compensation, and the Chancellor judged that

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the time had arrived to offer resistance to the Navy. The G.Q.G. was absorbed with the French attacks in Artois, and with Mackensen's advance after Gorlitza, and took little interest in the submarines. Falkenhayn, overwhelmed by the Austrian outcry at Italy's entry into the war, was anxious to induce Bulgaria to fight and to placate the neutrals. The Emperor and public opinion were on the Chancellor's side, and on 31st May, at a Council of War held at Pless, Tirpitz and Bachmann were alone in advocating the continuance of submarine warfare as it was being carried out. William II. signed an order that neutral vessels were to be spared, and, a few days later, that no passenger boats were to be sunk even if enemy ships. To heal the Grand Admiral's wounded feelings the Emperor a few weeks later sent him the order "*Pour le Mérite*," which was received with emotion, but not with joy. His was not the nature to accept defeat in consideration for a riband, and fresh agitation was commenced against the Chancellor, who was but feebly supported by his friends. To secure peace the Chancellor dismissed the Reichstag.

A few days later the *Arabic* was sunk without warning, in violation of the Emperor's orders. On this Bethmann acted vigorously, and Bernstorff at Washington hastened to assure Wilson that the event was due to an error of the submarine commander, who had been punished, and that Germany was fully disposed to indemnify the victims. Tirpitz and Bachmann were sent for and met by the Chancellor, who told them that he wished to be able truthfully to telegraph to Washington that passenger ships would not be sunk without warning. They then proceeded to see the Emperor, where Tirpitz's habitual haughtiness left him, and he proposed that all submarines should be withdrawn from the British Isles and sent to the Mediterranean. He agreed to dispatching a conciliatory note to America, insisting only that the principle of submarine warfare should not be sacrificed. Bachmann was less compliant and argued that it was not necessary to send to Washington "a declaration of weakness." If it was necessary to appear conciliatory it would suffice if the Chancellor were to request commanders not to sink passenger ships without allowing measures to be taken to save the passengers, and that this should be published in the press. Next day von Treutler, Bethmann's representative on the G.Q.G., came to Tirpitz and told him that the Emperor had directed the Foreign Ministry to address to Washington a note in Bethmann's terms, and on the Admiral's ejaculation that he should be consulted in the wording of the note, v. Treutler replied that it had already been sent. During the day the Emperor's order that no more submarines were to be dispatched for war against commerce "until the situation was cleared up" was communicated to Tirpitz and Bachmann. In the evening Tirpitz, Bachmann and v. Pohl asked to be relieved of their duties. Von Pohl, a mediocre personality, was merely told that he had nothing to complain of in the Emperor's orders. Bachmann, pre-eminently a soldier and with no political influence, was dismissed. Since Tirpitz in retirement could be very troublesome, his resignation was refused, and a strong letter was addressed to him stating that the Emperor declined to consult him regularly on naval matters when matters of

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policy were also involved, owing to the impossibility of collaboration between him and the Chancellor. In spite of the bluntness of the imperial letter v. Tirpitz felt that he was feared, and was confirmed in this opinion by the number of influential visitors who came to assure him of their devotion. With this support the Grand Admiral repeated his request to be relieved, declaring that " he could not remain in his position if he was not consulted on questions which were the very reason for its existence." The Emperor yielded, and replied, " It is my intention to ask your advice on all important naval questions," an extraordinary concession from a supreme ruler, and indisputable proof of a clash of authorities which was the true moral cause of the defeat of the Empire.—(*To be continued.*)

The Rupture of the Bulgarian Front at Dobro-Pole. The article by Capt. Paul Casson is concluded.—It is a wretched story of continual friction between Bulgarian Headquarters and the German Commander and Staffs, the one issuing orders, the other countermanding, or evading compliance with them. The broad outlines of each day's events are narrated. After three days of registration, 11th to 13th September, the attack opened with a violent bombardment on 14th. Next day the infantry advanced, directing their main attack just where it had been expected by the Bulgarians. The first position Dobro Pole–Vetrenik was overwhelmed, many of the defenders deserting without firing a shot. On 16th an attempt to hold a second position on Mount Koziak with the remnants of the two brigades defeated the day before and such reserves as could be collected, ended in failure. Although the defence held in other sectors, the centre had been definitely breached and the inner flanks of the 11th and 1st Armies were exposed. The retreat of the 2nd and 3rd divisions gradually deteriorated into a rout, demoralization spread to the two adjoining armies, large bodies from which deserted and in many cases drew off with them reserves which were hastening up to the front. Bold attacks on the flanks of the Allied salient by troops drawn from the more quiet sectors might have changed the fortunes of the battle, but the Germans would not risk attack. Or a general retreat to a position further to the rear, which could be consolidated without interference from the enemy, might bring some success, but again the Germans refused to retire the 11th Army in time, possibly from fear of uncovering the left of the Austrian Army in Albania. By 25th the situation appeared to be so hopeless that the Bulgarian government sent a flag of truce and asked for an armistice, addressing their proposals to General Milne, commanding the British Expeditionary Force, and soliciting his mediation with the French Generalissimo. The general retreat, already begun, continued until 29th, on the evening of which date the armistice was signed, to commence at 11 a.m. on 30th September. The Germans seem to have withdrawn their troops and staffs, including the German and Austrian reinforcements then arriving, in time to escape the consequences of the armistice.

Duties of the High Command in Regard to Economics.—The article by Pierre Bruneau is concluded.—The former portions have not been mentioned in the *R.E. Journal*, but it may be of interest to record that in France instructions have been issued that the army is to be thoroughly

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imbued with a knowledge of modern economic problems. A course of political economy has been introduced into the military schools, and at the *Ecole de Guerre* " military science is considered inconceivable if it is not closely associated with the other sciences." The special training is completed by lectures bearing on the great political, economic and social questions which exert their influence on the conduct of war. Visits to workshops supplement the theoretical instruction. Pupils from the administrative services study commercial methods. The writer regrets the abolition of the economic section of the General Staff, or rather its absorption into different sections of the 2nd Bureau. In case of another war the high command ought to have records on which to base its economic mobilization which only a service constituted for that purpose can provide.

Allied Strategy and Operations in the North. The article by Capt. Kuntz is continued.—In this number he deals with the Belgian scheme of defence based on Antwerp, and its want of harmony with the plans of the remainder of the Allies. The military value of the fortresses of Antwerp and Maubeuge is considered, and the investment and capitulation of the latter shortly described.

Evenings on the March.—A series of reflections and aphorisms selected from a book which is being written by one of the most distinguished French officers of high rank, who wishes to remain anonymous. Many of them are more appropriate to French conditions, others are of more general application. The book should be of interest as an expression of French Army opinion on military matters.

Bibliography.—The following books are favourably reviewed:—

Le 1er Corps d'Armée pendant la guerre, 1914–1918. (Berger-Levrault.)—Written by the General Staff of the 1st Army from official records and individual recollections.

La conduite de la guerre jusqu'à la bataille de la Marne. By Lieut.-Colonel Grouard. (Berger-Levrault.)—Lieut.-Colonel Grouard is well-known as the author of the *Maximes de guerre de Napoléon* and *La guerre eventuelle*. The strategy of the early days of the war is subjected to strict investigation. The writer holds that the victory of the Marne was not the consequence of Gallieni's action, but entirely due to Franchet d'Esperey's offensive. He argues that if this had been deferred for two days the whole of the German right wing, imprudently pushed forward by von Kluck, would have been enveloped. The blame for losing this opportunity rests with Gallieni, since it was by his insistence that Joffre decided to attack. The reviewer is sceptical as to the beneficial results of any delay, and asks whether the morale of Sarrail's and Langle de Cary's armies could have stood the strain of two more days of retreat. Besides, there were many ardent partizans of an offensive on 6th September at General Headquarters, who should all share the blame, if any there be, with Gallieni.

A. R. REYNOLDS.

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CORRESPONDENCE.

HOT-WATER APPARATUS, CHANAK KALE.

SIR,

With reference to the Report on "Hot-Water Apparatus" contained in the Professional Notes of the June number of the *R.E. Journal*:

The note at the end reveals the fact that this article has, to some extent, missed its mark. The furnace and coil as used are not an essential part of the scheme at all, and are the outcome of purely fortuitous circumstances, *i.e.*, the materials of the coil happened to be lying about and the simplest possible furnace was made to fit them. There is nothing subtle about the furnace or coil—the latter would have been a boiler if chance had willed it, in which case the furnace also would have been quite different.

The article was published in order to bring to notice results which are attributed entirely to the points mentioned in (*c*) and (*d*) of para. 3, which are summarized in the last sentence of that paragraph.*

Similarly, the results alluded to in the first part of para. 5 are attributed entirely to these same two points with the addition mentioned lower down in para. 5.† In this latter case these three changes (total cost, 32s.) were the only ones made in an apparatus on the old lines, so the improvement could hardly be attributed to anything else.

I must apologize for taking up your time again, as I feel that if the article has not been fully comprehended it is certainly the fault of the article itself, for which I am partly responsible.

Yours sincerely,

K. B. S. CRAWFORD, *Captain, R.E.*

The Editor, *R.E. Journal.*

* This paragraph reads:—Captain Crawford's contention is that the admission of the cold-water supply to the bottom of the cylinder, instead of to the boiler, and the extension of the return pipe up to two-thirds the height of the cylinder, results in a continuous flow of hot water to the baths.

† (*f*) Secondary return delivering into the cistern at a height above the bottom equal to two-thirds the height of the cistern, *i.e.*, at the same height as the primary return.

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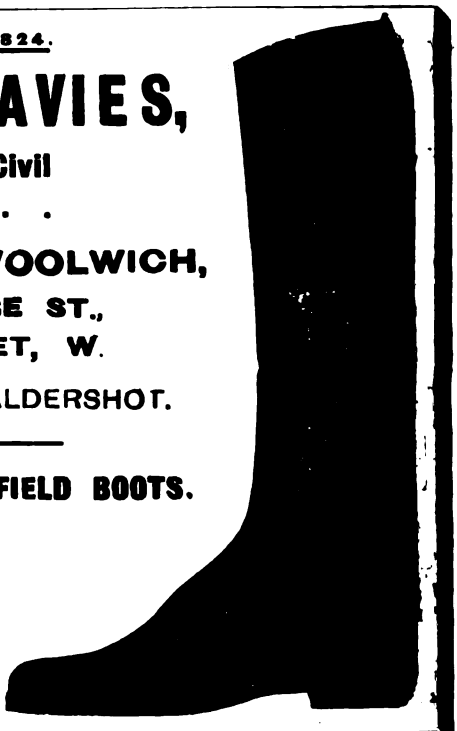

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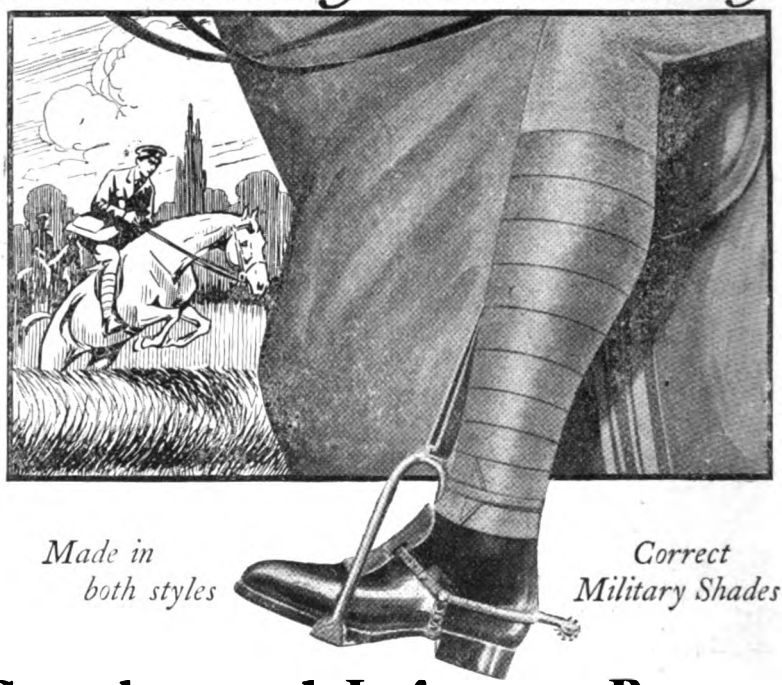

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THE LATEST METHODS OF ROAD CONSTRUCTION FOR HEAVY MOTOR TRAFFIC.

A Lecture delivered at the S.M.E. on 25th October, 1923.

By BRIG.-GENERAL LORD MONTAGU OF BEAULIEU, K.C.I.E., C.S.I., C.I.M.E., A.I.C.E., Memb. Inst. of Transport.

THERE are various aspects of roads on which I could speak to-night. There are those which concern the financial and the engineering points of view, while there is also the commercial, the political and the national value of roads to be considered. In addition to these there is the military aspect, which specially concerns you. But I must confine myself to the subject of this lecture, although a few general remarks by way of preface and conclusion, however, are permissible.

The origin of roads dates back to the earliest times, when, thousands of years ago, the paths used by man followed the tracks beaten flat by wild beasts through dense undergrowth in temperate climes, and the jungles in tropical countries. When the civilization of Rome was at its zenith, the road-maker was busy, as he is always where civilization is most progressive and of a high order. But it is remarkable that from these Roman times to the days of Napoleon, Macadam and Telford, a period of about 1800 years, the world boasted no famous road-makers. Most of the roads made by the Romans degenerated in a century or two into uneven trackways, fit only for riding or for pack animals, and it was not till the end of the 18th century and the beginning of the 19th that the increase and demands of wheeled traffic compelled more attention to roads. The military needs of European wars between 1800 and 1815 and General Wade's campaigns in Scotland led to a revival in road-making in order to increase the mobility of troops and facilitate their supplies. It is an interesting fact that all the great road systems in Europe and Asia, and, in fact, all over the world, had their origin in wars, or invasions by armed forces.

The change which has taken place in our system of transport and design of roads since 1900, when motor-cars and lorries first began to be used considerably on our roads, is in reality and not only in name, a revolution. Twenty-five years ago the only mechanical vehicles allowed were traction engines moving at four miles an hour and preceded by a man with a red flag. Axle loads in these days did not exceed six to seven tons, and long periods elapsed between the passage along a road of one mechanically-propelled vehicle and the next. Now we have lorries with axle-weights up

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to 10 tons moving at comparatively high speeds in their tens of thousands in every direction. In addition, the speed of the ordinary motor-car has commonly risen to about 30 m.p.h., and these conditions have altered the problems with which the road-maker has to deal to such an extent that, in my opinion, new methods are needed to withstand the traffic of to-day and of the near future. The two methods by which this can be done are, firstly, by the gradual reconstruction of some of our roads, and, secondly, by the building of new trunk roads designed from the beginning to carry the heaviest and fastest traffic.

The structure of a modern road outside urban areas may be defined in general terms as a triple-section pavement laid on mother earth. First of all there are the foundations which are all important. Secondly, upon them is built the lower section of the crust—the sub-crust, as it is called. And, thirdly, on the surface we are now placing a layer of some sort called a "carpet" made of various materials such as asphalt, tarred granite chippings, bitumen and sand, or of some other semi-plastic and water-proofing material. The chief cause of the destruction of any road is the passage over it of heavy weights moving at fast speeds, and the blows delivered and the impact caused by the bumping of heavily-loaded wheels against any obstruction, however slight, on the surface of the road or on the further side of a pothole. If a road could be made so that it would remain absolutely smooth the wear would be small. Then there are other destructive agents such as great heat or cold, heavy continuous rains or movement of subsoil. Sometimes the temperature of the surface may be as high as 160° Fahr. under a midsummer sun and as low as zero in winter. Nine-tenths of the actual destruction is not caused by surface wear, as is the popular impression, but by the movement of the individual stones in the bed, or sub-crust of the road underneath the carpet. It is quite a common experience when pulling up a modern road for repairs to find the stones on the surface in their original positions, and only slightly worn, the natural broken angles being still quite sharp. But the stones below will be found worn and rounded like water-worn pebbles in a river-bed or on the seashore. This process of internal wear is called inter-attrition. Some years ago, on the London and Exeter–Southampton road, near Staines reservoir, a new layer of red granite was placed on the existing worn gray granite beneath. In course of time, when this road began to bear heavy traffic, the mud on the surface was gray in colour, though the surface material was red, showing clearly that the wear taking place was in the sub-crust of the road, a proof of the truth that it is inter-attrition and not surface wear which chiefly destroys a road.

In regard to heavy mechanical vehicles, the maximum axle weights allowed by law and the regulations made under it, have been

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increased recently from 8 to 10 tons. Heavy motor vehicles are also allowed to draw two trailers (at a reduced speed), and the combined loads sometimes run into considerable weights. The power vehicle weighs, say, with its load, 10 tons, and two trailers 5 tons each, or 20 tons in all. Sometimes, at a slower speed, a traction engine weighing at least 16 tons can be seen drawing three trailers each of 8 tons weight, making a total weight in the four vehicles of 40 tons. With loads such as these our highways, bridges and culverts, in addition to public service mains conveying water, gas, etc., have to bear stresses for which they were never designed when built say 15 to 20 years ago. And the cracked culverts, walls and ceilings in villages situated on much-used roads testify to the shocks caused by this new heavy traffic on the road structure.

To appreciate what these weights mean, especially the axle weights, I would ask you to remember that to-day, in railway locomotive practice, the axle weights of the heaviest express passenger types—such as the latest Great Northern type—and of the heaviest goods locomotive, do not exceed 21 tons per axle, while the majority of locomotives do not reach 20 tons load per axle. As traction engines have often an axle load—quite illegal—of 12 tons, and ordinary motor vehicles 10 tons per axle, you will see that we are asking the road to-day to bear, in some cases, more than 50 per cent. of the weight borne by steel rails weighing 100 lbs. or over to the yard. It is clear, therefore, that a revolution in the system of road-making will have to take place if roads are to stand such great weights without constant and costly remaking and strengthening. Perhaps we shall have even to return to plateways, where heavy traffic is continuous, as the most economical form of road, though the first cost is heavy. In addition to this, the ordinary speed at which the average commercial vehicle is driven far exceeds the legal maximum of 12 m.p.h. In daily practice on the open road commercial motor vehicles up to 10 tons total weight, without trailers, exceed 25 m.p.h.—20 m.p.h. being a very usual speed—and with trailers, 15 to 18 m.p.h. If the smallest amount of corrugation exists on the road surface, the bumping action set up by such vehicles at such speeds is most destructive to the surface and especially to the sub-crust and even in the foundations.

The diagram illustrating impact which is shown in FIG. 1 on page 540, indicates how quickly the force of the blow delivered increases with speed.

Road engineers have been searching for some years for the type of road which will not disintegrate under heavy fast-moving loads, and for the perfect surface, or at any rate, the surface which will not corrugate. The real cause of corrugation is still unknown, scientifically speaking, whether on roads or rails. It is natural,

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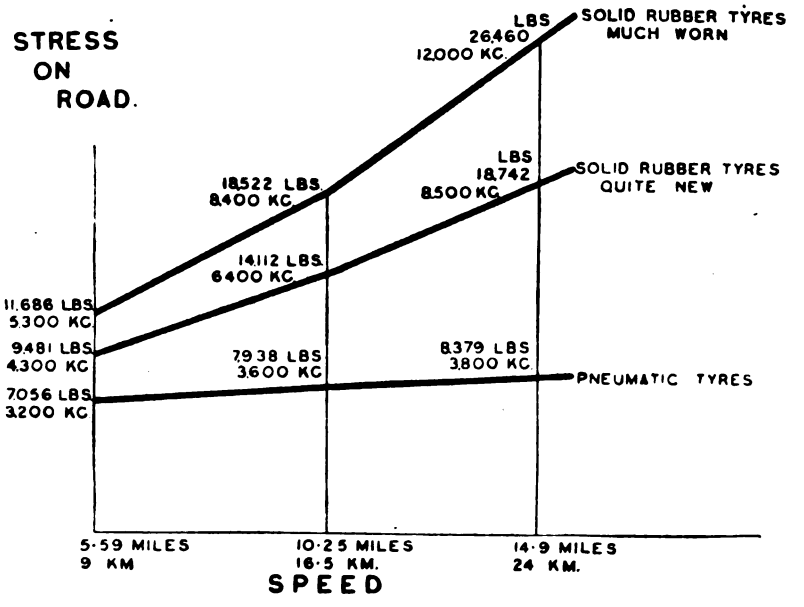

FIG. 1.

therefore, that a great deal of attention should recently have been concentrated on concrete roads, either carpeted or not, for concrete to a large extent seems to resist corrugation. In the U.S.A. to-day there are over 10,000 miles of such roads, most of which have borne their loads fairly well so far. But from my own observation of such roads there, here, and in other countries, I am not sure that our present system of laying concrete is ideal for anything connected with surfaces. As a foundation, however, or as a super-foundation or sub-crust upon breeze, broken stone or chalk, concrete, reinforced or not, presents many advantages. But the effects of heat and cold in the contraction and expansion of concrete are difficult to provide for. If we leave joints, either longitudinal or transverse, the edges of these joints are soon damaged by the traffic, and if the joints are filled with bitumen and sand or some other filler, when the concrete expands in summer this mixture is squeezed out, producing disagreeable results to boots and wheels. Again, every winter gaps reappear, and when they are refilled, the same process of extrusion takes place the next summer. So far as our experience in this country is concerned, although it is more expensive, it seems better to put a carpet on a concrete road, either in one or two layings, and the joints or cracks then look after themselves or are not so serious. In the diagram, FIG. 2, you will see the system as at present in use on the Winchester Southampton road, which will shortly be bearing traffic amounting to nearly 5,000 tons a day. There are also instances of similar construction in Middlesex, where there are

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TWO-COAT BITUMINOUS ROAD SURFACE AS LAID ON SOME MAIN ROADS IN THE COUNTY OF HAMPSHIRE.

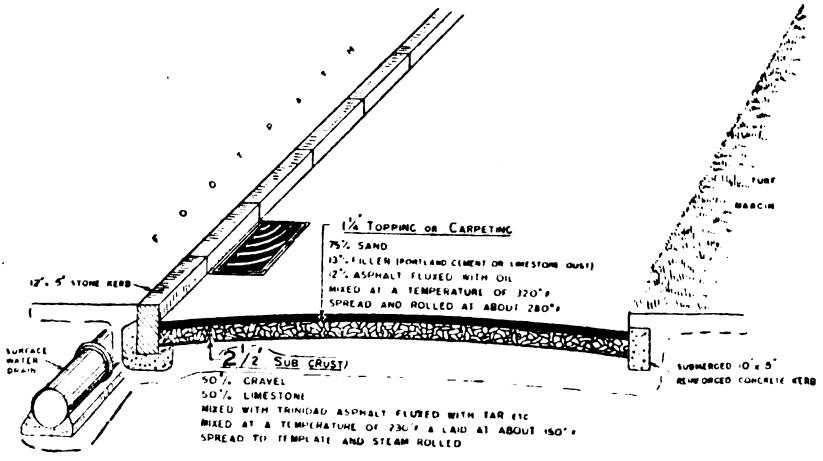
1¼ TOPPING OR CARPETING
75% SAND
13% FILLER (PORTLAND CEMENT OR LIMESTONE DUST)
12% ASPHALT FLUXED WITH OIL
MIXED AT A TEMPERATURE OF 320°F
SPREAD AND ROLLED AT ABOUT 280°F
12" × 5" STONE KERB
SURFACE WATER DRAIN
2½ SUB CRUST
50% GRAVEL
50% LIMESTONE
MIXED WITH TRINIDAD ASPHALT FLUXED WITH TAR ETC
MIXED AT A TEMPERATURE OF 230°F & LAID AT ABOUT 150°F
SPREAD TO TEMPLATE AND STEAM ROLLED
TURF
MARGIN
SUBMERGED 10" × 5" REINFORCED CONCRETE KERB

FIG. 2.

now roads with 9 in. of plain concrete and 2 in. asphalt carpet, costing altogether about 15s. per square yard. On the well-known Bath road east of Colnbrook, there is a stretch of road made on the two-coat carpet plan which has been down for ten years and has required very little maintenance, and in this case there appears to be several years' life still left in the surface.

Taking a number of roads which are known to me, I should say that, with a traffic of about 5,000 tons a day, a two-coat bituminous carpet, laid on a solid foundation of tarred or grouted macadam or concrete, should last at least 15 years. For the first five years the cost of maintenance should be negligible. During the next five years the cost should not exceed 3½d. per super yard, and 6d. to 7d. should cover the cost of patching and partial renewal from the 10th to the 15th year. Even then the surface should have some useful life left. Therefore, in my opinion, which, I am glad to say, is confirmed by competent county surveyors, though we have not been able to obtain any absolutely accurate data (because the system has not been in existence long enough) I think I may say that a well-made road on this principle, even with a heavy and fast traffic of 5,000 tons a day, should stand for 15 and possibly 20 years without entirely resurfacing. In the case of the Northern & Western Motorway, with which I am associated, on the 226 miles' stretch of road between Uxbridge and Liverpool, we hope to make various tests with regard to different surfacing and foundations, and the present plans are to use 9 in. of concrete, possibly reinforced, and on a portion, at any rate, of the road we hope to try both concrete carpeted and uncarpeted.

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Besides the concrete road there is the grouted road, of which there are many good examples. This is made of hard stone rolled in with some bituminous substance such as the "Invicta" fluid. Owing to the homogeneous character and wear-resisting qualities of this form of construction, and owing to the sub-crust being amalgamated thoroughly with the foundation and carpet, combined with a certain amount of internal resilience, the grouted road promises to last at least as well as any other method of road-making and it resists corrugation very well. There is a piece of such road laid five years ago running through Epping Forest, and another stretch on the Great North Road near Potter's Bar, both in good order. Another instance of this may be seen near St. Albans on the Holyhead road, where a road made on this principle was laid nearly ten years ago, and even now presents a very fair surface, though it is slightly uneven in places. The average traffic at this point, as shown by a recent census, is about 3,500 tons per day. The cost of a grouted road is about two-thirds, or even less, compared with a road built with concrete and carpeted.

The third, and, in my opinion, the only other type of road (outside urban areas) which will bear continuous heavy and fast traffic with any degree of success, is that made of stone setts. Types of this road may be seen in many parts of Lancashire, in some of the streets of London, and in the ancient and modern *pavé* of France. This type of roadway, though expensive to build, costs very little to maintain if properly constructed, that is, with the setts laid in sand and jointed with bitumen or tar. In fact, the wear-resisting qualities of such a road are probably superior to that of any other type. But against this must be put the disadvantage of increased noise and a certain roughness of surface, the former being a nuisance to the frontagers and ordinary users of the road, while the roughness produces a jarring effect tending to intensify the wear and tear of mechanical vehicles passing over it. I am unable to deal here with other roads of the town type, such as those made with wood blocks or specially-laid asphalt.

I now sum up the types of road suitable for ordinary modern traffic on our trunk roads in order of their resistance to wear, as follows :—

(1) Stone setts ; (2) concrete with a two-coat bituminous carpet ; (3) macadam grouted with bitumen.

Nos. 2 and 3 may, in the opinion of some road engineers, be reversed, and I admit that experience so far shows little between them, but grouted roads are more difficult to build up properly. As to our old-fashioned water-bound roads made with hard stone or gravel and rolled in with water and mud, these are useless when traffic is at all heavy, and the annual repair bill is so high that at the end of ten years or less it would have been cheaper to scarify

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the upper crust of the road and make a new waterproofed surface on any of the three systems I have outlined above.

As to the cost of the three types of road, stone setts may be taken as costing somewhere about 35s. to 40s., reinforced or ordinary concrete with a two-coat bituminous carpet about 15s. to 17s., and grouted macadam about 8s. to 10s. per super yard.

In regard to the repair and maintenance of all types of road, the watchword should always be: "Patch in time." Once potholes begin to develop, every wheel, even those lightly loaded, intensifies the damage, and in a very short time, especially in wet weather, the surface is worn through and the sub-crust becomes exposed. Water then may get through to the foundations of the road, leading to serious disintegration when the first frost and thaw occurs, for the road, being sodden, will then expand and contract, and the area round the pothole will prove a sore not easily healed.

There is another type of road which is now in an experimental stage but has many points of interest. Rubber blocks keyed on to an asphaltic base and to expanded metal are being laid on concrete. Such a system is to be seen laid three years ago in St. George's Road, Southwark, and more recently in Whitehall. The cost of such a road is about three times that of wood-paving, namely 85s. to 90s. per super yard. In Southwark the cost was 90s. and in Whitehall, which was laid about two months ago, I am told the cost was 80s. to 85s. Such extra expense can only be justified on the ground of such a surface outlasting other methods, or being superior in some respects. I am all in favour of this experiment with rubber being carried further, but I should doubt whether, at the present moment, the wisdom of laying any of the principal main roads of this country on a large scale with rubber blocks is proved either from an engineering or financial point of view.

The cost of maintaining roads compared with tonnage conveyed is showing a tendency to fall, owing to stronger methods of construction. In the year 1890, in the neighbourhood of Glasgow, it cost ·36d. to carry 1 ton 1 mile, and this figure fell to ·28d. in 1910, rising slightly in 1922 to ·31d.; these are cheering figures, even though the gain in economy to the ratepayer is relative and not actual.

If heavy and fast traffic is a serious matter on Class 1 or main roads, with a grant of 50 per cent. of the costs from the Road Fund annually, it is clear that on second class and unclassified roads construction and repair are a greater problem. These unclassified roads include something like 80 per cent. of the total mileage of roads in this country. Where second class or unclassified roads have not been strengthened recently, the heavy traffic has already done considerable damage, and the expense to local ratepayers of road-making and mending is bound to increase. Even supposing the Class 2 roads can stand, with the grant of 25 per cent. from

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the Ministry of Transport, the strain of modern traffic, there remains still the serious problem as to how the expense of maintaining the unclassified (or, as they used to be called, 3rd class) rural roads of this country is to be met in future. It is obviously unfair to ask the local ratepayers, already highly rated, and often local tradesmen, to help in keeping up to a standard not required locally a road over which rivals from a neighbouring town bring goods to compete with them in heavy motor vehicles. In the country districts, also, the principal local ratepayers in general, such as farmers, do not see why they should contribute nearly the whole cost of 3rd class roads over which perhaps 75 per cent. of the traffic nowadays is of non-local character. Without going further into this controversial subject, you will understand from these remarks that the problem of who is to pay for the new heavy and fast traffic on our roads, especially the 3rd class roads, is by no means easy to solve. In fact, I may say that, difficult as are the engineering problems of the road-maker to-day, they are easy compared with the financial problems and the settlement of the proportion to be paid by the user, the ratepayer and the taxpayer, and that is the State.

Of course, the ideal to aim at, at any rate in the main roads of this country—we will call them national trunk roads—is that a road should be built like a sound building of any kind, to last more or less for ever. Nor is there any engineering reason why this should not be done. It is a question of the first expense of sufficiently good foundations, the discovery and application of the perfect surface and the cure of corrugation.

Flat roads or plateways, without camber, have been suggested. I need hardly tell an audience of Royal Engineers that it is far more scientific, at any rate in theory, to continue to make roads on the principle of the flattened arch, varying the camber from 1 in 66, or even less in the case of very wide roads, to 1 in 33, or even more on roads less wide, with inferior foundations. Recently I have heard of experiments with a type of road laid like a floor, with sleeper walls of concrete or steel joists, and slabs of concrete or steel placed upon them. I do not say that such a road may not eventually be devised which will show unusual wearing qualities and retain its shape. But I fear that a flat construction will tend to sag in the centre, or unevenly, and, in addition, there is always the problem of drainage, which, without camber, would mean a central drain if not transverse gratings or drains as well.

In conclusion I will mention the general principles which the progressive road engineer should bear in mind. Primarily, he should think of roads as being made suitable for the traffic rather than the traffic made to suit the roads. This axiom must not, however, be pushed too far. Everything has its limits of strain, including roads, and co-operation is essential between the designer and user of the

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vehicle, and the road-maker. Much can be done by proper design, by the resiliency of springs and tyres, and the reasonable limitation of speed and weight

Roads are great national institutions and transport is the life-blood of the nation, ebbing and flowing through its arteries and veins. Cheap and rapid transport, moreover, is essential to our commercial prosperity, more now than at any former time in our history. Railways, which some thought twenty-five years ago were the final and best method of transport, we see now have limited uses, and are unable, except in few cases, to deliver from the place of origin to the destination. And as, in this country, no important manufacturing district is more than 120 miles from a seaport—for instance, Birmingham to London Docks—unlike America, where manufacturing districts are sometimes a thousand miles from the seaboard, it follows that a form of transport in which many handlings can be avoided is one which, in the long run, must gain in popularity in these days of the high cost of labour. Except in cases of the most heavy and cumbersome goods, for which the railway is the best carrier, transport without intermediate handling from the factory door to the shop or to the ship's side should be the ideal for commerce.

But road transport, though it costs more for power per ton mile than rail trausport, may yet be cheaper. It may be asked why this should be so. You will recall the calculation that it needs a 15-lb. pull to move a ton carried on a clean steel wheel running on a clean steel rail. Even on the average smooth carpeted road it takes about 40 lbs. to move a ton on a rubber-shod wheel, or nearly three times as great an exertion of power. This disparity is considerable, but it has been calculated that each average handling in connection with goods sent by railway transport is equal in cost to about 11 miles of actual moving by rail. It will be easily comprehended, therefore, that handling has become more important and more costly than the extra power required per ton to move an equal load. Power, in fact, in recent years, has become cheaper and labour dearer, till the advantage of the lesser consumption of power has disappeared. That, in my opinion, is the real scientific reason underlying the growth of road transport. We are now at the commencement of a new era of road transport and we must prepare for it. For the purposes of peace and war alike we must realize that nowadays roads must convey heavier loads at high speeds.

From the military point of view, in which you are particularly concerned, in the British Army to-day over 75 per cent. of the tonnage in wars in countries with roads will be conveyed at some period in mechanical road vehicles, and for a successful campaign, therefore, designers and constructors of roads, and armies of road-makers, will be needed. That is where you come in. The lesson taught everywhere in the Great War—in France, India, Italy and Palestine,

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was that good roads, military mobility, and rapid and easy transport, are the necessary preludes to the successful issue of any campaign. Cæsar and Napoleon, in their times, grasped this fact—the immense value of " road power " in war.

Twenty years ago Rudyard Kipling said that " Transportation was civilization." I can go further than the new Rector of St. Andrews to-day and say, " Good roads make a nation." There is no more interesting, wonderful and inspiring profession than that of Road-maker—he who smooths Earth's rugged bosom for the service of man.

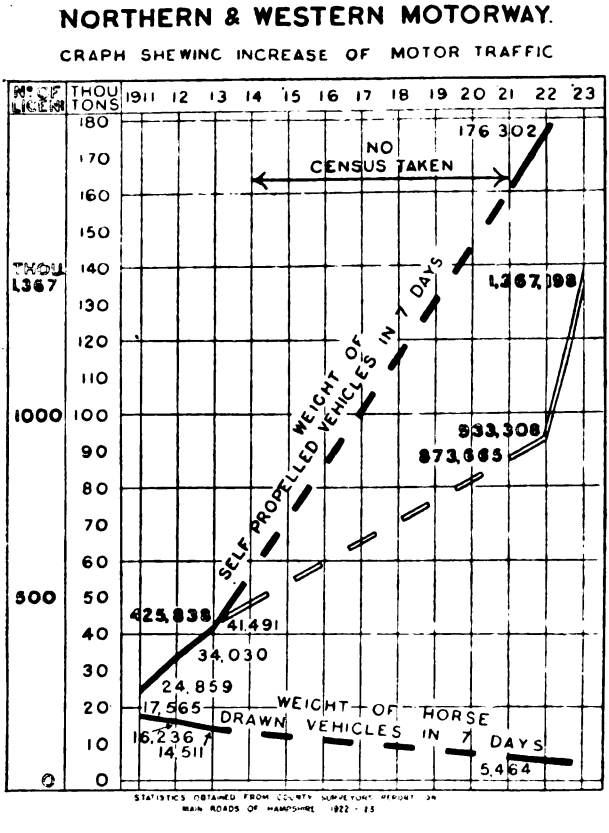

FIG. 3.

The author desires to express his acknowledgments to Mr. W. J. Taylor, County Surveyor of Hampshire, for the use of the diagrams.

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THE DISMANTLING OF HELIGOLAND.

By COLONEL J. C. MATHESON.

THE inhabitants of Heligoland can hardly have welcomed the results of their transfer from the sovereignty of Great Britain to that of Germany in 1890, as it has entailed so many changes in their minute island. It was a pity for them that " self-determination " had not been invented then, as they were not asked their opinion on the subject. Within a year of the island's coming under the sway of the Kaiser changes began which greatly altered even the physical features, and the process continued until the Great War broke out.

To the south of the rock a large war harbour was created for destroyers, submarines and sea-planes, with repairing shops and stores. The Unterland, that short strip of beach at the south of the island, certainly remained much as it had been, but the Oberland suffered many changes. It is at best but a very circumscribed area, a triangle some 1600 yards long with a 600 yards base. Outside the little town it had consisted of potato fields. These had to be curtailed severely. Room had to be found for large barracks, while the fortifications took a heavy toll. The very contours of the table-land were altered greatly when the North Group of guns was installed on a miniature mountain, fashioned out of the material blasted out of the rock in forming the maze of subterranean stores and war shelters. (*See Plan*).

After all this was done the area left for potatoes was very small, but the " Kartoffel Allee " remained to preserve their tradition.

Then the Great War came and Heligoland has felt its results, more, perhaps, in proportion to its area than any other place within what one may call the " radius of rupture." At the beginning of the war those Heligolanders who had retained their British nationality were imprisoned, and the remainder were all removed to Blankenese, near Hamburg. The close of the war and the Versailles treaty brought fresh changes, since Heligoland as a base had to be dismantled.

An interesting article in *Smith's Dock Monthly* for June, 1923, by Admiral Sir Edward Charlton, K.C.B., the head of the Naval Inter-Allied Commission of Control, gives an account of the actual dismantling. If any of the inhabitants of Hamburg, who used to flock to Heligoland for their summer holiday, have been in doubt as to who won the war, their next visit will answer the question.

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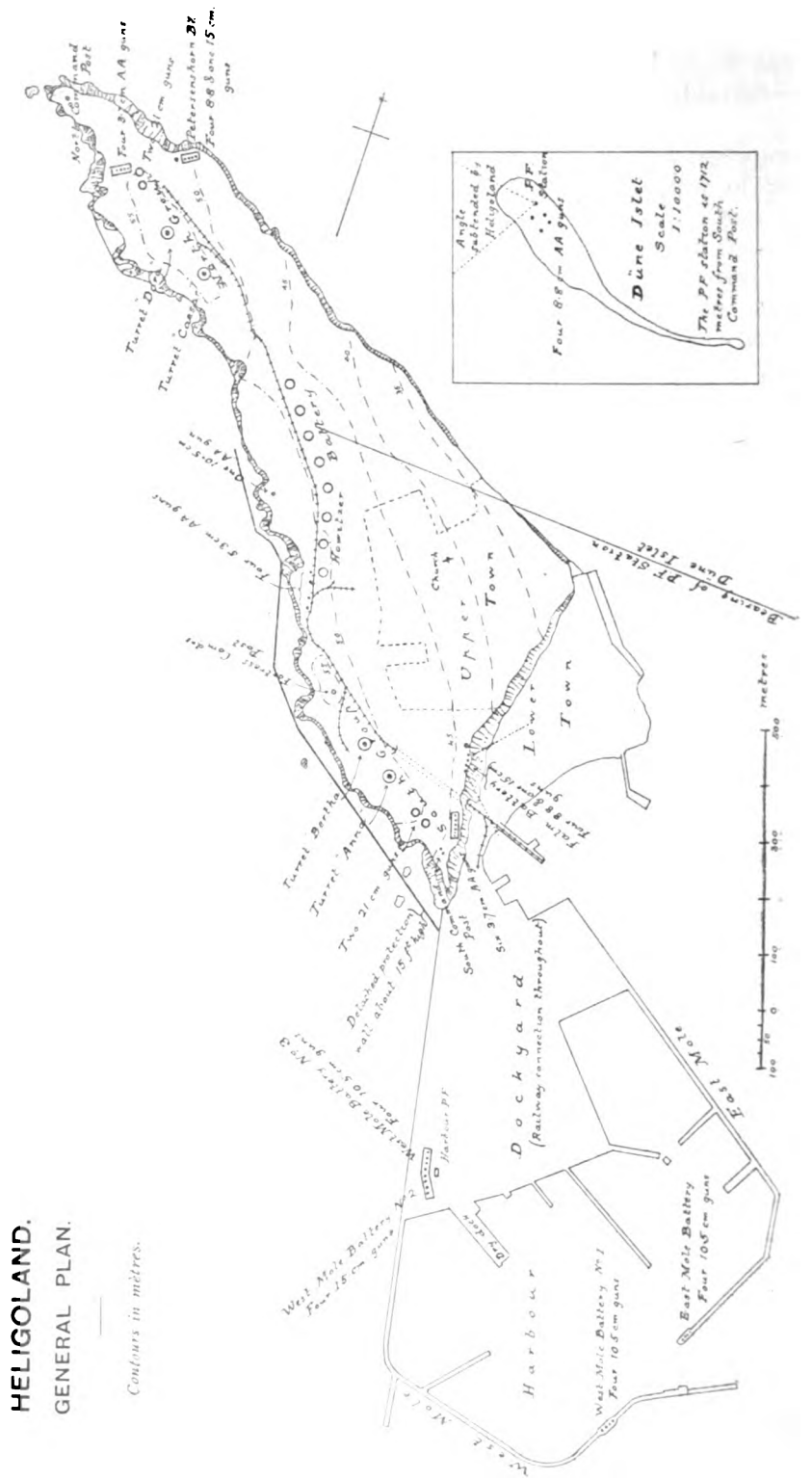
Dune Islet
Scale
1:10000
Lower Town
Upper Town
Dockyard
Harbour
East Mole Battery
Four 10.5 cm guns
West Mole Battery No 1
Four 10.5 cm guns
West Mole Battery No 2
Four 15 cm guns
Turret Dora
Turret Caesar
Turret Berthe
Turret Anna
Two 21 cm guns
Four 8.8 cm AA guns
Four 8.8 cm guns
Four 3.7 cm guns
Four 10.5 cm guns
Six 3.7 cm AA guns
Six 8.8 cm guns
Two 3.7 cm guns
Two 8.8 cm guns
Two 10.5 cm guns
Two 3.7 cm AA guns
Two 8.8 cm AA guns
Two 10.5 cm guns
Two 3.7 cm guns
Two 8.8 cm guns
Two 3.7 cm AA guns
Two 8.8 cm guns
Two 3.7 cm guns
Two 8.8 cm guns
Two 3.7 cm guns
Two 8.8 cm guns
Two 3.7 cm

The war harbour no longer exists, its remains now constitute a rocky shoal which shelters the old anchorage from the westerly gales. The fortifications are demolished and the underground works filled in and the potatoes are triumphant.

The Heligoland Sub-Commission, of which the writer was for some time a member, arrived at the island on H.M.S. *Coventry* in February, 1920, to superintend the business of demolition. Two days after arrival they met the German Commission and arranged procedure. Naturally, the meeting was not characterized by its cordiality, but no exception could be taken as to the correctness of behaviour on both sides. The work of demolition was carried out by some 500 to 600 Germans under the supervision of the Sub-Commission, and the men worked well and gave little trouble.

At first some German mine-sweeping vessels used the harbour as a base and their crews showed obvious disapproval of our presence. This was manifested by assembling outside the hotel which served as quarters, singing "Deutschland über Alles" and throwing a few stones at the building. However, this was quickly stopped and an apology was tendered by the O.C. Mine-sweepers. It is rather interesting that the author of that Teutonic-soul-stirring effusion composed it at Heligoland years ago, whilst he was sojourning there under the British flag. The singing referred to above took place round a statue of the author which has been erected there.

Admiral Charlton mentions three points of special interest in the work of demolition:—

(i) *The War Harbour.*—The German Commission included the engineer who had constructed this and now he had to assist in its destruction, surely a unique record. The sides of the dry dock (which projected into the harbour) were blown up, the moles had their foundations destroyed by explosives, and the winter gales, always heavy, soon made them a mass of ruins. The reclaimed ground, on which stood the dockyard buildings, had openings made in its retaining walls and the sea sucked out the millions of tons of sand brought from the Elbe for its formation. Thus the whole place has been wrecked in such a way that no new harbour could be constructed on the site.

(ii) *The Fortification Works.*—The engineer officer on the German side of the Commission had been "C.R.E." of Heligoland for some time during the war, and he, like the harbour engineer, must have found it a unique experience to "hand over" to a Royal Engineer officer and conduct the latter through all the intricacies of the Kaiser's "Holy of Holies." His distasteful task was, however, carried out with dignity.

The fortress, as Admiral Charlton remarks, resembled a huge unsinkable battleship, the guns being in turrets and most of the works were underground. These were demolished systematically.

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Party walls were removed, a few pillars being left. These were then blown up and the roofs fell in. (*See* Photo of South Group taken before demolition of the supporting pillars. The wire-netting was to prevent the projection of pieces of concrete, etc. The Photo shows the two-metre roof of ferro-concrete.) The resulting spaces were then filled in and planted over.

(iii) *The Destruction of Metal Structures.*—Most of the guns were in turrets or cupolas and the control stations and P.F. cells were also armoured, so that there was a vast mass of metal to be cut up and removed. To effect this, the oxy-hydrogen or oxy-acetylene flame was used for steel and the pure oxygen process for cast-iron.

The guns and turret armour were all cut up by one of the first two processes, the gases being contained in cylinders at a pressure of 150 atmospheres. To one who had not seen much of the process previously it was intensely interesting to see the 16-in. steel armour of the turrets being cut up in this simple manner.

The armour round the turret beds was chilled cast-iron (the French technical term for it being "*avant-cuirasse*"). It was of the usual section of a curved mark of exclamation. To cut this up the pure-oxygen process was employed. The gas, contained in cylinders at a pressure of some 115 atmospheres, was led to the point of application by flexible tubing ending in a long length of steel tube, about ½-in. external diameter and five-sixteenths inch internal.

To start the process, the end of the steel tube was first heated to redness and the oxygen turned on through it. The gas combines with the steel at the heated end and the combustion, once commenced, continues, the steel tube being quickly burned away as the metal operated on is melted. The process is based on the fact that the heat produced by the combustion of steel and oxygen is much higher than that required to melt cast-iron.

The average length of steel tubing required per lineal foot of 3-in. hole burned into the armour was 20 ft., and the time taken just half an hour. The holes thus made were charged with explosive and the metal was broken up, about 1½ lbs. of explosive being required per ton of metal operated on.

All the cut-up metal was removed to Germany and sold for the benefit of the Allies.

The Germans originally stated that the dismantling would take seven years to complete, but by bringing pressure to bear on them and by altering a few plans the work was completed by the 1st June, 1922, the last item being the destruction of the inclined tunnel from the Unterland to the Oberland.

Then Heligoland was left to take up its old life as a summer resort only. Under the new conditions none of its inhabitants remain British citizens, all are now German. They are an interesting people, some 2,500 in number, Scandinavian in appearance, pleasant

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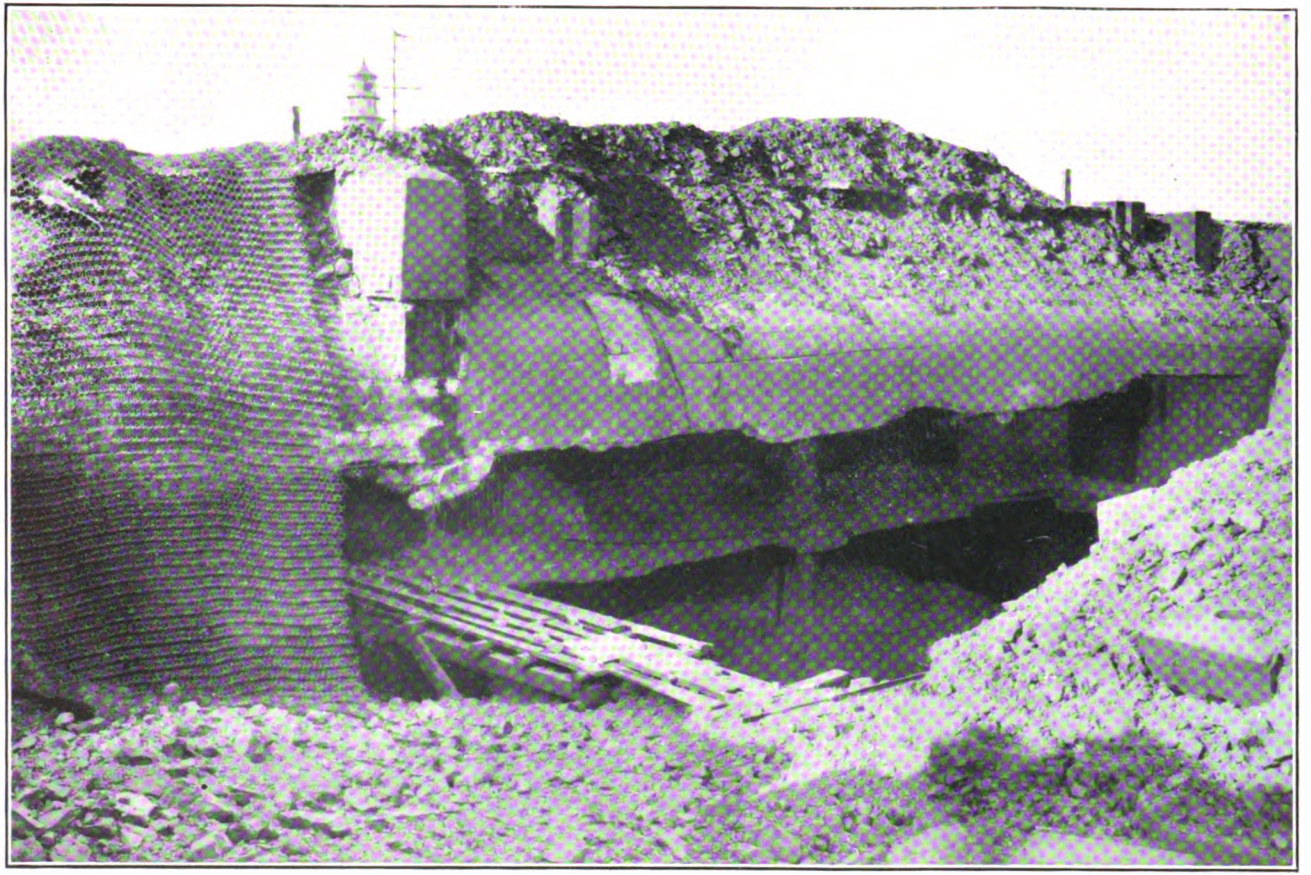
THE DISMANTLING OF HELIGOLAND.



Turret of South Group, showing Underground Decks before Destruction.

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and courteous in manner and devoted to their island home. Admiral Charlton mentions that Heligolanders, when asked what they did in the winter, replied that they counted the money which they had made in the summer. He says that they well sustained their reputation for grasping which all islanders are said to possess (not excepting ourselves !).

They show little sign of dying out, judging from the number of children. In fact, one wonders whether Mr. Mellin, who was a Heligolander and invented a well-known food for children, had been inspired by the sight of the little streets of his native land when school was being dismissed. The children, like their elders, were most friendly to the small British detachment. One small maiden gave one of the officers of the Commission as hard a task as he had had for many a year by coming up and demanding that he should start her whipping-top for her.

One of the first inhabitants to meet the Commission was a pensioner of the Royal Navy, a fine specimen of a man. He had been unable to receive his pension for some years and was anxious to see about it.

The visible remains of British rule are not many, the outstanding ones being the little Government House and a bronze tablet on the church tower, with an English inscription commemorating its erection. Search in the churchyard revealed only one tombstone with English wording, erected in memory of a drowned sailor.

Admiral Charlton adds that the fortifications and harbour had cost Germany 35 million pounds and that the garrison during the war was 4,300 strong. He also reveals the fact that during the winter of 1916–17, when the German rivers were frozen over, 66 submarines used Heligoland as a base, and mentions that during the two months of the frost 30 million pounds' worth of damage was done to allied shipping.

Even allowing for the proportion of the loss to us caused by the existence of the Heligoland base one cannot but wonder if most of the money spent on the island could not have been used in some manner more useful to Germany.

With the departure of the Commission in 1922 it would seem that British interest in Heligoland can now be only sentimental and historical.

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THE TECHNICAL EDUCATION OF THE SOLDIER.

By MAJOR G. C. GOWLLAND, R.E.

IN Part I of *Educational Training* it is stated that "the aims of educational training are to continue the general education of the soldier in order to improve him as a subject for military training" and "that every means must be taken to ensure that the same attention is paid to strengthening the mental capacity of a soldier as is devoted to ensuring that he is at all times physically capable of enduring the strain of active service. The certainty of constant new inventions in warfare tends to make the success of operations depend more and more on the intelligent initiative of junior N.C.O.'s and men."

It is clear from this that those shaping the educational policy of the army realize that men must be mentally well grounded before they can assimilate mechanical facts, and that the better educated the man the easier it will be to instruct him in the intricacies of modern machines.

One aim of the Army Educational Corps is, therefore, so to train the mind of the soldier that he will be easily able to assimilate the technical knowledge that his particular Corps considers necessary.

In order to mark a man's progress in general knowledge, the Army Educational Corps have devised the certificate system. Each certificate gained means that a man has passed one milestone on the road of general knowledge. The passing of the first milestone, *i.e.*, the obtaining of a Third Class Certificate of Education is compulsory; men are ordered to school and learning is thrust on them.

Having obtained a Third Class Certificate, men are encouraged and given every facility to gain the Second and First Class as well.

In technical units there is another side to a man's education, *viz.*, his Trade Education.

In every trade there are three classes, each class gained meaning that a certain trade proficiency has been reached. In 1920 the system of grading a soldier's trade proficiency was standardized; that is to say, there was an Army system of grading, certain fixed tests for every Army trade being laid down, together with the standard of excellence required for each and every class; those responsible for framing these tests, at any rate as far as the R.E.

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are concerned, having arranged such tests roughly on the following system :—

A Class III man must have a knowledge of his trade, but need only be moderately skilled at it. He is only expected to do bench work.

A Class II man must be a first-class man at his trade as far as bench work is concerned, but in addition must have certain more general knowledge of things which do not come into the range of experience of all men of his trade.

A Class I man must, in addition to being a first-class bench hand, have still more general knowledge.

What it amounts to is that a second-class man, however good with his hands at bench work, can never attain first-class trade pay, as to gain this rate of pay he must have theoretical knowledge of his own and allied trades.

Take the trade of fitter as a concrete example :—

A Class III man does simple bench fitting jobs, and must be able to use, grind and sharpen all ordinary fitters' tools.

A Class II man must be able to produce work accurate to 2/1000 of an inch, in fact, be a rather more skilled man with his hands than Class III, and in addition must be able to dismantle, overhaul and re-assemble one type of service prime-mover (I.C., or steam), and must have a knowledge of the principles of construction and action of all types in use in his Corps.

A Class I man must, in addition, be able to overhaul, test, and prepare for test any machine used by his Corps—a pretty large order. To be capable of overhauling and re-assembling an engine, a fitter must know how such an engine works. Before he knows how an engine works he must have some knowledge of the theory of steam or internal combustion engines. Before he can test an engine he must know how to take its brake horse-power, and he must also be capable of taking and reading ordinary indicator diagrams.

A man with no theory cannot, according to the recognized trade tests, rise above Class III in his trade. The question arises, when and where is the man to learn such theory? Where is the Class III fitter to learn to take indicator diagrams and test engines? Where is the Class III mechanical draughtsman to acquire a good knowledge of the elements of internal combustion, hydraulic, electrical and steam practice? Where does the Class III painter learn to have a good knowledge of the principles of paint-spraying, stove-enamelling and dipping methods?

These questions are being asked by various disgruntled soldier tradesmen who, though first-class men as bench workers, lack knowledge of theory, and consequently fail to pass their trade tests when examined by Area Trade Testing Boards. The function of the

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Army Educational Corps is to prepare men's minds so that they will more easily absorb technical knowledge. It does train, to a limited extent, "handy men" at Vocational Training Centres, but the Class III tradesman has got beyond this; besides, a "handy man" cannot pass a Class II test.

No courses are run for training sappers in the theory of their trades, and yet the Army demands that tradesmen should have such knowledge. It is true that pioneers, *i.e.*, men below Class III, can obtain a six-month's trade course, at the end of which they blossom into Class III tradesmen, but here, unless they be exceptional men, their trade career will end.

It is also recognized that a limited number of men receive training as fitter-drivers at Gosport.

There seems to be some flaw in the educational system as applied to technical units.

A sapper enlists at, say, 19 years of age, is mustered as a Class III tradesman, and obtains his Third Class Certificate of Education. He is ambitious, and he, therefore, works on till he gets his First Class Certificate of Education; this, given he has application, he can get without much trouble. He is provided with books, with an instructor and with a place in which to work.

Suppose his ambition is to be a first-class tradesman, what encouragement does he get? He must have book knowledge, but the Army is not always in a position to provide the necessary books. He must have technical knowledge, but the Army provides no instruction. He frequently cannot even practise the manual side of his trade.

It is fairly obvious from experience gained in trade-testing men for the Class II and Class I rates that the technical education of the rank and file is being overlooked by company and other officers. It is clear that many such officers still have the idea that a man skilled with his hands can get Class I trade rate, otherwise sappers totally ignorant of many parts of their trade test would not be sent up to the Area Trade Testing Boards.

The company or section officer spends much time in teaching his men to shoot, dig, tie knots and turn smartly to the right or left. A sapper who has not been given preliminary musketry drill is not allowed on the ranges, yet men are sent up for trade tests without even knowing what sort of test they are supposed to pass.

It is clearly an advantage to the Corps to have as many Class I tradesmen as possible, yet no system seems to exist for helping men to improve in their trade. Such assistance should presumably be given by the company or section commanders, but apparently this assistance is not being given. An officer may not go up for his promotion examination without a certificate stating that he is in every way fit to undergo the test. A sapper, having failed in his

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trade test, may do six months in the cook-house and yet be allowed to go up and have another try for a higher rate of pay—usually a perfectly hopeless proposition.

It is true that in A.C.I. 789/20, para. 7, it is laid down that "The O.C. units will forward to the President of the Command Testing Board the names of men whom they recommend for test, stating that they consider them sufficiently qualified to be tested."

Every man comes up for Trial of Trade, therefore, with a certificate stating that he is qualified to be tested. This certificate is frequently valueless.

How many C.O.'s signing this form have really taken the trouble to find out if their men are really fit to be tested?

The writer has in mind a candidate for test as bricklayer who arrived armed with his C.O.'s certificate of proficiency, but who could not build a plain 9-in. brick wall in simple English bond, much less take on a Class III bricklayer's test; yet this man was solemnly stated to be qualified to do any test set him.

Something further than a list of names with an officer's signature at the bottom is required. An actual statement that a candidate has been informed what is required of him, and has been found proficient therein by the actual officer signing his proficiency certificate, might wake up company commanders to the fact that they must take a lively interest in their men's trade training, and might be the beginning of some organization within the Corps whereby the missing links of the sappers' technical training are forged.

Corps Memo., Part II, para. 24, lays down that O.C., R.E. units, will take all possible steps to improve the trade skill of the men in their units. Presumably this means that men are to be trained within their units so as to be able to qualify for higher rates of pay. This entails the running of courses, etc., by units whereby sappers could be trained in the theory as well as in the practice of their trades.

In how many R.E. units do such courses exist, or are even contemplated, and in how many R.E. units are the full practical trade-training facilities of the district fully realized? *E.g.*, a field company is in a district where there are first-class engine rooms working pumping plants, etc. In how many instances are sapper tradesmen encouraged to work in such places with a view to bettering their trade skill in the case of engine-drivers, or enlarging their sphere of usefulness in the case of the fitter? Men of the latter trade, encouraged to work with engines, will soon blossom into the fitter-driver—a trade in which there is a Corps shortage.

The Field Company commander will probably justly protest that he and his men have no time for such things, but for all that, though the practical side of trade training may present difficulties, owing to lack of time, the organization of theoretical training within units should be easy.

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All R.E. officers are capable of giving their men lectures that would assist them in the technical side of their trades. Incidentally, this would keep the officer up to date, besides helping the men.

Trades roughly divide themselves into the sub-heads of metal-workers and the building trades.

In every R.E. company there are at least two subalterns. The business of the one would be to take on the coaching of the metal, and of the other the building trades. This could be done in the winter. The mere attempt to teach men on these lines would impress on the officer what is required of his men by the Trade Testing Boards. It would, in time, become a point of honour to get men through their trade tests, and ways would be found whereby sappers could be helped in the practical as well as the theoretical side of their trades. Men are proud to be in the best shooting section of a company. Why should not men be proud of being in the best trade section?

Nine times out of ten it will be more beneficial to the Corps to have a section of first-class tradesmen than a section of first-class shots. There is no reason why the shooting should not be learnt during the summer and the trades during the winter. It is merely a matter of keeping up the summer training pressure all the year round.

There are other advantages. The officer in a field unit tends to lose touch with the technical side of his profession. If he has to deliver a series of lectures during the winter on, say, the theory of steam and heat engines, he must perforce read up his subject, and by so doing will keep himself up-to-date. At the same time, the fact that the officer takes a keen interest in the man's trade proficiency will tend to foster the good feeling between officer and man.

A strenuous programme, perhaps, soldiering all the summer, engineering, etc., during the winter, but, unless some effort is made, the technical efficiency of the Corps must drop. Few really good tradesmen enlist; the ordinary recruit is young, of low trade skill, and has very little experience outside his own particular rut, for civil practice tends to keep trades in water-tight compartments.

The Corps wants men of more general knowledge, and must accordingly train them, as they cannot be got by direct enlistment.

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SOME NOTES ON THE DESIGN AND CONSTRUCTION OF A POST ON THE NORTH-WEST FRONTIER OF INDIA.

By CAPT. G. MACLEOD ROSS, M.C., B.ENG., A.M.INST.C.E., R.E.

I.—HISTORY.

THE North-West Frontier of India is guarded by a mass of hills and desolate country, the only paths through which are provided by sundry river valleys.

Roads have, from time to time, been built for varying distances up these valleys, and are held by bodies of regular troops or militia of various strength, located in posts or forts situated every 12 miles or so along the roads.

The international boundary between Afghanistan and British India is the Durand line, which lies in the midst of the hills. Going east, the first natural boundary is the River Indus.

Our frontier policy varies from time to time, and depends on the prevalence of the views of either the "forward" school (the hold-up-to-the-Durand-line school) or the back-to-the-Indus brigade. As occurs with so many problems in India, the *via media* is followed, and we find ourselves, in Waziristan, for the most part in river valleys held up to points between 30 and 60 miles from the Durand line.

The garrisoning policy has, of late years, consisted of an outpost line of militia who are controlled by the civil authorities, supported at some 20- to 60-mile distance by regular troops. In 1919 the Afghan Army advanced on British India between the Tochi and Kurram valleys. Regular troops were not available in sufficient numbers to support the outlying militia posts and the withdrawal of their garrisons was ordered. Datta Khel, at the head of the Tochi valley, was such a post, and its garrison was withdrawn to Miranshah, some 23 miles east.

On evacuation, the post was burnt and its further destruction was assisted by local Wazirs, who became hostile to us on the approach of the Afghan troops. In November, 1921, a mixed force re-occupied Datta Khel and the Resident in Waziristan made known to the local tribes the terms under which the "blockade" of the upper Tochi valley would be removed.

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A temporary post was erected 100 yards from the site of the old post wherein a militia garrison of some 300 sepoys was located, and the regular troops withdrew in April, 1922, to Dardoni.

II. PRELIMINARY RECONNAISSANCE.

As it was certain that Datta Khel would be permanently occupied, although there were no definite orders for the building of a new post, it was incumbent on the engineer to make a very complete reconnaissance of what remained of the post and of local conditions, *e.g.*, water supply, building stone, limestone, fuel, clay suitable for burnt bricks, timber supplies, possibility of obtaining unskilled labour from the local tribes.

There was no trace of timber or metal in the remains of the post, though some 60 per cent. of the walls were standing. Had, however, the original lay-out been followed, a further 10 per cent. would have had to be demolished.

Water supply was found within 100 yards of the post from an old *karez* or underground (artificial) stream, giving some 700 gallons per hour. A well, much damaged, and filled with débris (including a searchlight) existed inside the post. Failing these supplies, the Tochi river was distant two miles below the post.

There was no suitable building stone available nearer than four miles.

Limestone boulders for burning to lime were to be found in the small *nala* beds within 1½ miles.

Fuel was not within sight, save rough bushes, but arrangements to buy locally up to about three tons a day could be made, at a price.

Clay, suitable for burning to bricks, was available near the water supply.

So far, construction appeared to be possible on the site, whatever the temper of the local tribes.

Timber, however, comes from the forests on the hill slopes to the south and west, and great rough-hewn logs come daily on camels down the Tochi valley.

It was, however, expected that these might be held up or diverted by the local tribes. A "peculiar" feature of the local wood trade is the fact that the people prefer to carry logs an additional 60 miles and get a few annas increased price than to sell at Datta Khel and take a slightly smaller price.

Time seldom enters into the calculations of the Oriental.

The possibilities of obtaining, and the advisability of using, local unskilled (there is no skilled) labour was doubtful, and dependent on too many factors to be decided immediately. On demand a rough approximate estimate for rebuilding the post according to the original design was put in for Rs. 150,000.

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III. Requirements.

The original post consisted of a civil portion built on to a militia portion.

The civil post contained a double-storied section wherein were all the British Officers' quarters and the Political Agent's rooms, and it also provided accommodation for the civil staff charged with the administration of the tribes in the Upper Tochi.

The militia garrison, who are under the orders of the Political Agent as far as employment strategically is concerned, were housed in a self-contained post, considerably larger than, and immediately adjoining, the civil post.

In considering the design of these frontier posts, which invariably contain both civil staff and militia, a decision has to be come to as to which portion shall be looked upon as the "keep."

It is hard to find an all-sufficient answer, because:—

1. The militia garrison may mutiny;
2. The militia post (containing many rifles) may be rushed, as occurred at Tut Narai post.
3. The civil post has to keep more or less open house to all manner of local "badmashes" who may wish to "confer" (always at tremendous and illogical length) with the civil power, and consequently is liable to be overpowered or rushed more easily than the militia post.

It is, therefore, hard to decide which post shall command which.

The militia consider their men trustworthy, whilst the civil are usually casual to a fault about letting large crowds of locals into their portion.

The decision here was compromised by the fact that the civil portion could be rebuilt, and required no enlargement, and had previously contained the B.O.'s quarters.

Later practice at Spinwam post placed the B.O.'s quarters and the Political Agent's private rooms in the militia post on the party wall with the civil post, but on the first floor again.

The Chief Commissioner of the N.W.F. Province in December, 1921, laid down the militia garrison as 250 rifles and 30 horses—the original garrison had only been 70 rifles and 19 horses.

This was all the "higher" direction necessary, and it was then possible to approach the two persons directly concerned—the Political Agent and the Commandant of the Militia, and ascertain their detailed requirements.

India is a land of "followers," and one man never seems able to hold down a job without five others—servants, sweepers, bhistis, sowars, orderlies,—to help him.

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Consequently, the Political Agent's requirements comprise: All the civil officials and their servants; the Post Office and Postmaster and the telegraph linemen; the civil hospital and all the attendants; quarters for a Public Works subordinate and store; a lock-up for recalcitrant locals; water supply and latrines and cook-houses.

The militia, too, have to be self-contained, and, apart from sepoys, need tailors, bootmakers, a sweet-seller, quartermaster's store, garages for lorries and cars, wireless telegraphy rooms, magazines, armouries, all of whom or which have to be separately housed, either from caste prejudices or other considerations. An allowance of 40 sq. ft. per man is made in these posts.

With the above requirements obtained, the quickest and most satisfactory system to proceed on is to decide on a suitable span or width for the barracks and rooms which can be followed throughout.

This permits of uniform treatment for roofing and flooring throughout.

A rough ground plan showing the arrangement of all barracks and quarters is then got out, and this, together with accommodation statements, is discussed with the two persons respectively concerned.

At this juncture, too, all defensive requirements of the post are decided—the position of the gateways, towers, keeps, loopholes, magazines, guard-rooms, wells, reservoirs and capacity, and similar matters, on which the militia commandant has opinions. Owing to the fact that the garrison is largely used for "ghust" purposes (*i.e.*, a strong offensive patrol is often being sent out) it is essential that the militia post shall be defensible, during the absence of the patrol, by a minimum garrison. The perimeter, therefore, of the post must be reduced as much as possible, which means, usually, that the post will be double-storied.

The other determining factor in the size is the number of buildings, such as horse standings, bathing places, which of necessity fill the quadrangle.

It is then possible to get out a more detailed ground and first-floor plan. All these documents are signed as approved, to avoid later controversy or change of opinion with change of command.

The money for a post of this size has to be granted by the Government of India, and it is essential, before any specification is decided upon, that the Government should say how much they are willing to spend on the project. A rough idea of the probable cost is arrived at by the plinth area method for any given specification, but conditions have changed so much of late years that few reliable data are available on which to arrive at a plinth area rate for such a post in potentially hostile country.

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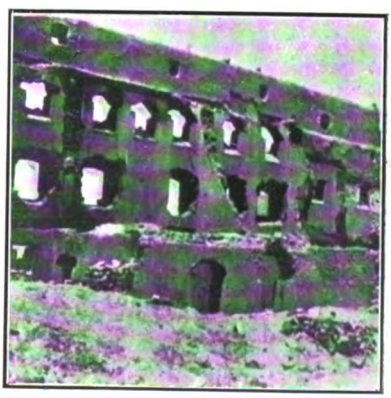
DATTA KHEL POST

General View.

Exterior. Civil Post.
Before re-building.



Interior. Civil Post.
Before re-building.

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IV. Specification, Design, Estimate, etc.

The post is sited on hard gravelly ground, and foundation trenches were only taken down one foot (4½ ft. wide) and filled with lime concrete.

A plinth protection of 3 ft. of rammed shingle was allowed, tapering from 6 in. to ½ in.

The walls of such a post may be of a variety of natures :—

1. Stone in lime and/or mud.
2. Burnt brick in lime and/or mud.
3. Sun-dried brick in mud.
4. A combination of burnt and sun-dried brick in two skins.

The lower storey may be *pucca*, *i.e.*, either stone or burnt brick, with the upper *kachcha*, *i.e.*, sun-dried brick.

Apart from the diversity in the initial cost of these, consideration has to be given to the maintenance costs which the various designs incur. Generalizing, of course, the higher the initial, the smaller the recurring costs.

Official India tends to low initial cost, regardless of maintenance charges.

In this case stone is prohibitive, owing to the long carry. Burnt brick can be used but sparingly, because fuel is dear. It is not, therefore, difficult to arrive at sun-dried brick as the medium for the bulk of the work. External walls were 3 ft. thick with protected walls 1½ ft. thick. Protected walls were built with B.B. in mud ; pillars at 8-ft. centres to support roof joists.

Burnt brick in lime was given for :—

> Fireplaces, chimney stacks above roof level, 4 courses at top of walls, 2 courses below bedplates.

All verandah pillars were B.B. in mud, lime pointed. Walls are finished mud plastered and leeped.

Roofing :—The cheapest form of roof is double matting on *bullies*, supported by wooden joists. It is also the coolest. In this instance, rolled steel joists supporting R.S. battens, to which were clipped 24-gauge corrugated-iron sheets, were used.

An instructive point arises here. The contractor is paid a percentage over certain standard schedule rates for his work. There is a schedule rate for mat-roofing on *bullies* and wooden beams, which means he is paid a percentage on the materials which he supplies as they are all included in the rate. On a rate, the bulk of which is made up of material, and the lesser portion labour, the flat percentage tendered for all rates in the schedule may become a source of loss on a certain rate. The labour rate for fixing R.S. joists is hardly more than for timber work. All the steel work and

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corrugated iron is purchased by the department, and no percentage, therefore, is paid on it. This, coupled with the low cost of steel joists at the time, made this specification advantageous.

As a protection from the sun, 4 in. of rammed earth with 1 in. of mud plaster was allowed over the corrugated iron. This arrangement of mud on C.I. sheet is sound so long as parapet walls are provided. Without these the rains wash off the mud very soon and high maintenance charges are incurred.

A roof slope of 1 in 30 is allowed. The necessity for standard spans for the buildings is here apparent, as all the steelwork was drilled in Karachi, on plans submitted, ready for erection, and a multitude of spans would have made erection and sorting a lengthy process. The parapet wall had, of course, to be defensible, and in this case a castellated wall was preferred to the loophole. The loophole has a bad moral effect on men, and the field of fire, unless it is a costly ball-and-socket type loophole, is very limited. Reinforced-concrete loopholes for the kneeling position were allowed at 25-ft. intervals along the parapet wall. On the inside face a parados wall was built, also castellated. All bedplates for R.S. joists were 3-in. cement concrete cast in position.

Roof drainage is by means of down-takes at 25-ft. intervals. These have to be very open as they have been used before to-day as a means of scaling the wall into the post.

Floors for all save European and superior quarters on ground-level were rammed earth. These are maintained and leeped weekly, or as wear occurs, by the occupants. Upper-storey floors were of $1\frac{1}{2}$-in. *chir* wood planks. Windows of barracks, to save wastage in glass and ensure ventilation, were all 3 ft. by 3 ft. battened clerestory type.

The guardrooms, lock-up, magazine and rifle *kōts* are all built in B.B. in lime to a height of 6 ft. above ground-level.

The magazine and rifle *kōts* are wholly-detached buildings within the post, commanded by a "keep" tower. The reason for this is that attack is occasionally made on the magazine by tunnelling.

Perhaps it should be mentioned that a round of S.A.A. sells for eightpence on the Frontier, and the short Lee-Enfield rifle goes for about £50 in the Khost bazaars.

The guardroom is placed next the main gate of the militia post and the gates of the two posts are sited together. To save the cost of bullet-proof steel doors, two brick screen walls are built out from the posts at suitable angles to protect the wooden gates from rifle fire and also to make the actual entrance way circuitous and less easily rushed.

Further, one sentry can supervise the two entrances.

The keep tower, which is sited at one corner of the militia post, furthest from the entrance gate, possesses a hinged iron ladder

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access to the first floor, and no entrance at ground level. It contains a supply of water and S.A.A. and, as already mentioned, commands the magazine, and the whole interior courtyard. The ladder being hinged, it can be pulled up in case of emergency. The keep tower is always garrisoned by a sentry group.

Surface drainage within the post is by means of standard gutters of three sizes, designed to present no danger to horses or obstacle to motor or wheeled traffic.

Water supply consists of two 4-ft. diameter wells, one in each post, steined with B.B. in lime, some 70 ft. deep. They are fitted with Boulton water elevators worked by hand-power, delivering 500 gallons per hour. This type of elevator is peculiarly suited to India. It is practically totally enclosed, it has no valve leathers or buckets to dry up, and the belt can be lengthened should the water-level drop. It is easily fixed at the top of the well. The elevator in the militia post delivers into a reserve storage tank built on ground-level storing 6,000 gallons, which is very ample with a potential reservoir within the post in the shape of the well itself.

For safety, and to ensure a reserve being always maintained, two draw-off cocks are fitted on the reservoir at different levels. The lower one is locked and can only be opened with the concurrence of the post commander, thus conserving some 2,000 gallons.

Bathing places, night latrines, cook-houses, stables, are included within the post, with incinerators and day latrines outside the post.

The estimate is prepared in the following sections :—

1. References to correspondence.
2. Report giving the cost and estimated time to complete.
3. Accommodation statements.
4. Abstract of costs.
5. Special conditions of contract.
6. Schedule of rates for all classes of work to be done.
7. Details showing how any special or unusual rates have been arrived at.
8. Calculations for all roof members, etc.
9. Specifications—separate for each class of building.
10. Detailed measurements for all buildings by classes.
11. Abstracted costs for each of the above.
12. Carriage charges.
13. Cost of kilns and plant, etc.
14. Cost of labourers' camps.
15. Payments to local *maliks*.
16. Stock charges and deductions from the contractor.

The drawings should show ground and first-floor plans and elevations and all details of particular construction.

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V. ADMINISTRATIVE DETAILS.

The system by which work is done on the Frontier hinges on a standard schedule of rates for each locality. This schedule covers all classes of work likely to be met with in ordinary construction. The contractor tenders at a percentage above or below the schedule.

The letting of tenders for a post in potentially hostile country, 60 miles from the narrow-gauge railway, of which only 40 miles is motor road, and the last 20 barely protected, is a somewhat precarious business. A poor contractor is useless because he may fail, and he may be unable or unwilling to "placate" the local head men or *maliks*.

This leads us to the political aspect. The local tribes were havering, our hold on them was small; we were about to start a 40-mile heavy M.T. road into the heart of Waziristan with no military protection, we could not afford to incur disaffection for this project costing 4·3 million rupees as against only 0·2 million for the post.

The local *maliks* naturally wanted to be their own contractors for the post—contractors in name, employing some scurrilous Hindu to do the work. We had not the troops to raise a siege of Datta Khel, should the tribes around rise and invest it, as all available troops were being concentrated for the occupation of Razmak, as soon as the road was built to support them.

Could the *maliks* be bought off by giving them a percentage on the contractor's payments, or by buying the timber from them, or by giving them a contract for unskilled labour? The last two sops cramp the unwilling contractor's style, and are not popular.

As usual, all the native political advisers were pessimistic, and for some weeks, full of "conferences" with filthy *Wazirs* in flowing robes, the question of whether the technical would be prostituted for political hung in the balance. Eventually the *maliks* agreed on a percentage and a reputable contractor was appointed—in this case there was no tendering, as the locality was regarded as too precarious.

The contractor imposed all manner of conditions contained in Section 5 of the estimate. These are many and wonderful.

We find that the Government will:—

1. Provide protection for labourers' camps, working parties, and and convoys of material.
2. Pay compensation for abduction of labour or animals and damage to the work resulting from enemy action, or neglect by the "protection."
3. Provide labour camps and wired staging camps on the road up—will clean and water them.
4. Guarantee 500 gallons of water per hour from the Karez.
5. Erect kilns, provide tools.

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It is truly hard to call these men contractors.

The protection is all arranged with the Political Agent, also the days on which the road shall be open for convoys and its protection on those days. The sites of camps along the road and the main camp at Datta Khel are agreed on with the Militia Commandant, who refuses to allow the contractor *all* the water, or to house local labour in his camp, etc.

It is possibly understandable that work does not run on ball-bearings for a day or so. Somehow, one day, something happens and another frontier post comes into being.

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DAM CONSTRUCTION IN TIDAL CREEKS.

By MAJOR E. ST. G. KIRKE, D.S.O., R.E.

WITH the object of freeing from civilian traffic the existing track over the Maplin Sands, which are used for military purposes, the W.D. is constructing a road overland to Foulness Island in South-East Essex. This road will have the additional advantage of giving access to the Island at all states of the tide, instead of for a few hours only each side of low water.

The "Broomway" (*Fig.* 1), as the track over the sands is called, owing to its position being defined by bundles of sticks stuck into the sand, has been in use from time immemorial and is mentioned in documents over 400 years old. It needs no attention apart from periodic renewal of the "brooms," and heavy agricultural steam-tractors and machinery weighing 15–20 tons can pass freely along it, except when an on-shore gale has deposited a layer of soft sand.

Between Havengore Island and Foulness lies another small island, New England, into which the sea broke 25 years ago. This island has never been reclaimed and is flooded every high tide. As the road had to pass over it, there appeared the alternatives of bridging it and the encircling creeks by a pile bridge, or of reclaiming the island and running the road on its surface.

The latter was decided upon, and this involved damming either the breaches in the sea walls of the island, or the creeks from which the breaches were flooded. By damming the creeks the maintenance of a long length of sea wall was eliminated, all bridging was dispensed with and the necessary arrangements for landing material for the construction of the dams could more easily be made on adjoining dry land. Further, the main breach in the sea wall had, in the course of years, become enlarged to a cross-section almost as large as that of the creeks, with a deep central scour over 10 ft. below its bed.

Originally it was proposed to construct four dams in the positions shown A, B, C, D′ on the attached *Plan*, but a more detailed examination of the conditions pointed to D′ being moved to its present site D (so that the road could be run over it) and the sea wall being raised or repaired on the portion between A and D, as being cheaper than the construction of the dam itself at A. It was of no advantage to move "C" dam to the line of the road, as this would have left the big breach at E still open to the sea, and the sea walls between the road and B had been practically destroyed.

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The actual method of constructing the dams proved an interesting problem, and for the better understanding of this a word must be said about the peculiarities of the tides. It will naturally be assumed that the tide comes in from and goes out towards the sea, but except for one or two hours before and after high tide the reverse is the case. The tide comes in from the Crouch, *i.e.*, from the land side, flooding the creeks till it reaches the level of the Broomway, which is nothing more or less than a watershed on the sands. When the tide has topped the Broomway from the land side it has also reached a similar level from the open sea, and, there being no restriction to its flow from the latter direction, it pours into the creeks, reversing its direction therein.

This feature of the tides had a considerable bearing on the best order for tackling the dams. If "C" dam were built first, half the water coming and going in New England creek would fill the reservoir formed by New England Island, and not have to pass over the site of the dam at all. Also, it would protect the site of B from the enormous volume of water hitherto draining over it from the Broomway.

Another consideration was that the creek at "C" dam was very nearly dry for one or two hours at low tide. It was, therefore, possible to form open foundations across the creek by diverting the last of the ebb from one side to the other, as occasion demanded.

The beds of the creeks are covered with mud to a depth varying from one to five feet, under which is generally, but not always, found a blue clay capable of bearing about three-quarters of a ton per square foot.

At one time it was proposed to drive a pile line across the creeks at the site of each dam, to keep the sea out while earthen dams were constructed behind them, but this scheme, while not impossible of fulfilment, presented very serious practical difficulties.

For one thing, the reversal of the tidal flow, referred to above, meant that each pile line would have to resist pressure from both directions unless the dams at each end of the creek were closed simultaneously, but the more serious difficulty lay in the volume of water to be controlled.

The creek at "B" dam, for instance, is 420 ft. across, and has a tide range of nearly 18 ft. on high spring tides, *i.e.*, from −5·5 ft. to +12·3 ft. O.D., with exceptional rises to +14·3 ft. O.D., without wave-lap.

It has been found that, when the channel is restricted to more than half its normal area, serious scour takes place, unless the bed is protected by heavy and expensive stone or chalk pitching. The corollary of this is that provision must be made for closing nearly 200 ft. of waterway on one tide.

To drive a sufficient number of piles for this purpose on one tide

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is, of course, impossible, and it was proposed to drive a lower line of piles, a few feet only above the bed of the creek as a preliminary. On to this lower line was to be fishplated an upper line of piles to give the necessary height. This upper line of piles could only have been closed on one tide by assembling them into shutters, laying them handy on the bed of the creek, and raising them into position by means of an aerial cableway, without interlocking the ends of adjacent shutters.

The difficulty, however, of driving the lower line of piles accurately to line and level was found to be almost insuperable, owing to the extraordinary resistance offered by accumulated oyster shells; and the two hours allowed by the tide for placing the shutters would have allowed no more than a few minutes each. When it is remembered that failure to place the last two or three shutters would have led to a destructive wash-out, and that two dams had to be closed at the same time, the probability of there being a better and cheaper method of tackling the problem became apparent.

Owing to the creeks at C and D being nearly dry for two hours at low water it was possible, as explained above, to excavate the foundations for the dams in the open, and this rendered piling unnecessary for sealing these two dams against underscour or infiltration.

There then remained, as materials of which to construct the dams, earth or concrete. Either would have to be protected against the rush of tidal water, restricted more and more as the height of the dam rose, but there was the essential difference that if the concrete survived twenty-four to forty-eight hours, according to the time of year, it would be hard enough to resist further attack, and in any case a wash-out would not destroy more than a day or two's work at the worst, whereas earth, if its protection failed, might, and probably would, wash out right down to the bed of the creek.

Further, the amount of earth required would be about ten times that of concrete, owing to its low angle of repose, so there was not much difference in the question of cost.

For these reasons concrete was decided upon. As regards handling it, the quantities involved clearly pointed to machine mixers and Decauville tip wagons for running it out to site. Also, in view of the distance, and lift over the sea-wall, hand-pushing was out of the question, so 20-h.p. petrol tractors were obtained from Longmoor, being kindly loaned by the Commandant, Railway Training Centre.

The obvious aggregate was Thames ballast, which could be brought by barges alongside the steam cranes on the military pier at Shoebury for under 4s. per ton (about $\frac{3}{4}$ yd. cube). Between the pier and the site of work existed a railway for three miles, and this was extended, with material mostly on hand, to each dam in turn. Cement also

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DAM CONSTRUCTION IN TIDAL CREEKS.

Fig. 1.

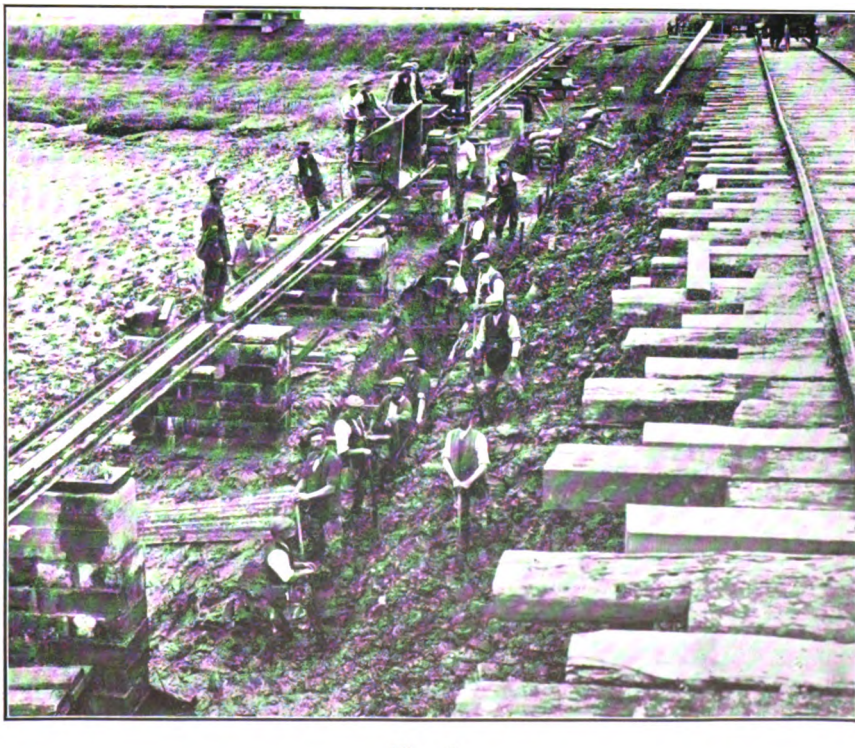

Fig 2.

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Fig. 3.

Fig. 4.

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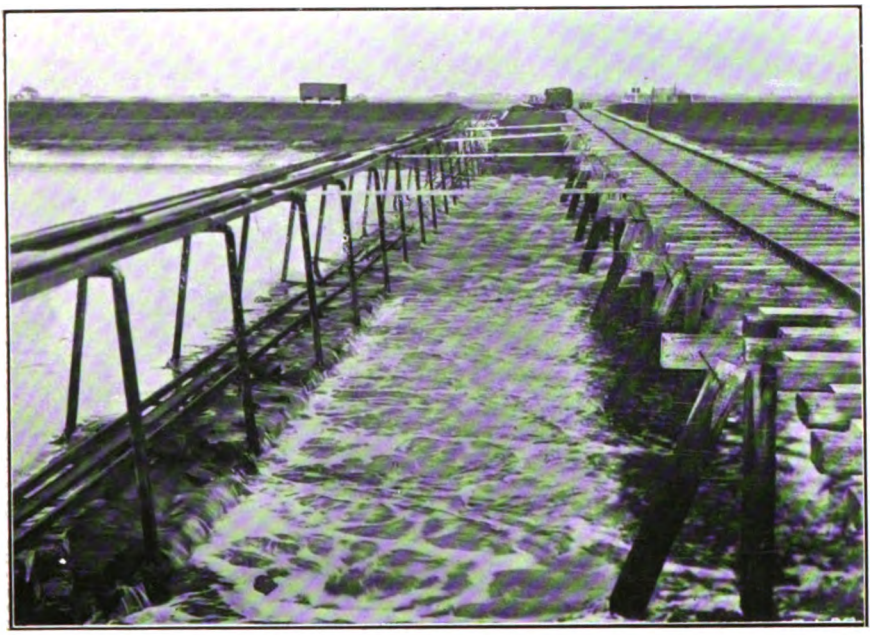

Fig. 5.

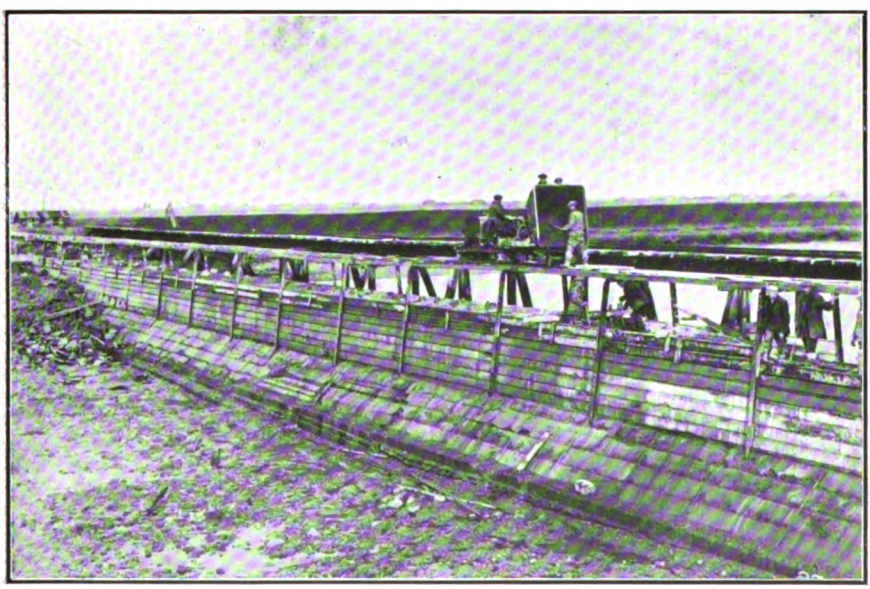

Fig. 6.

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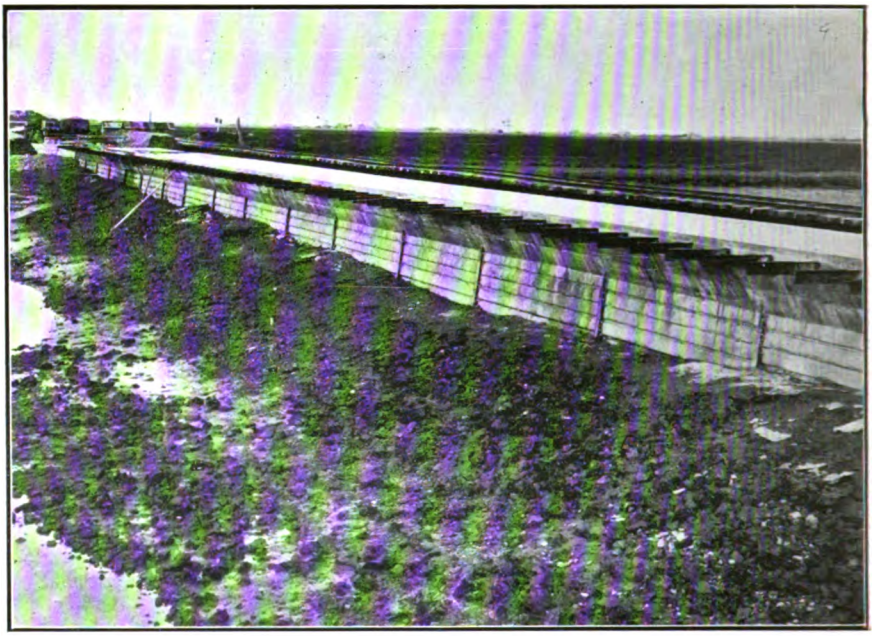

Fig. 7.

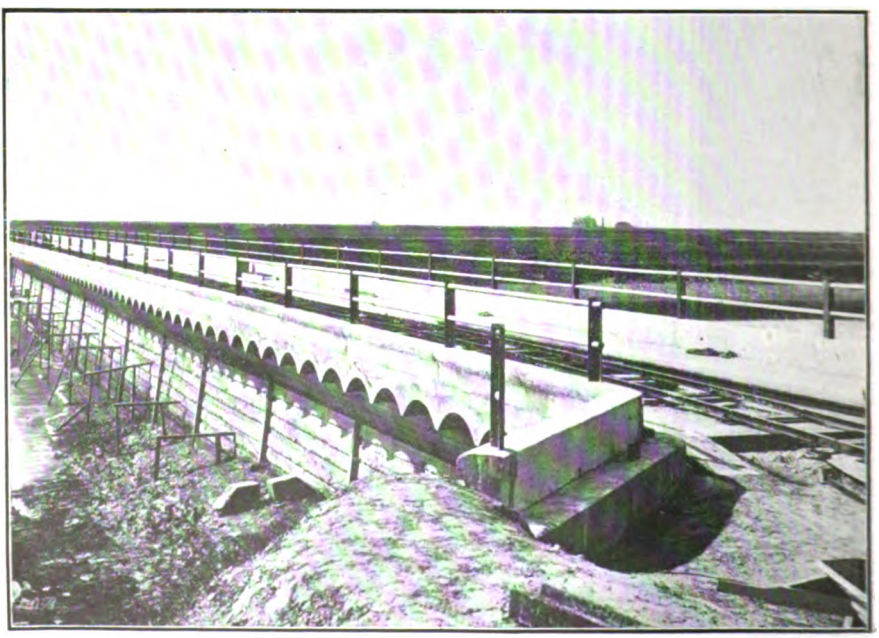

Fig. 8.

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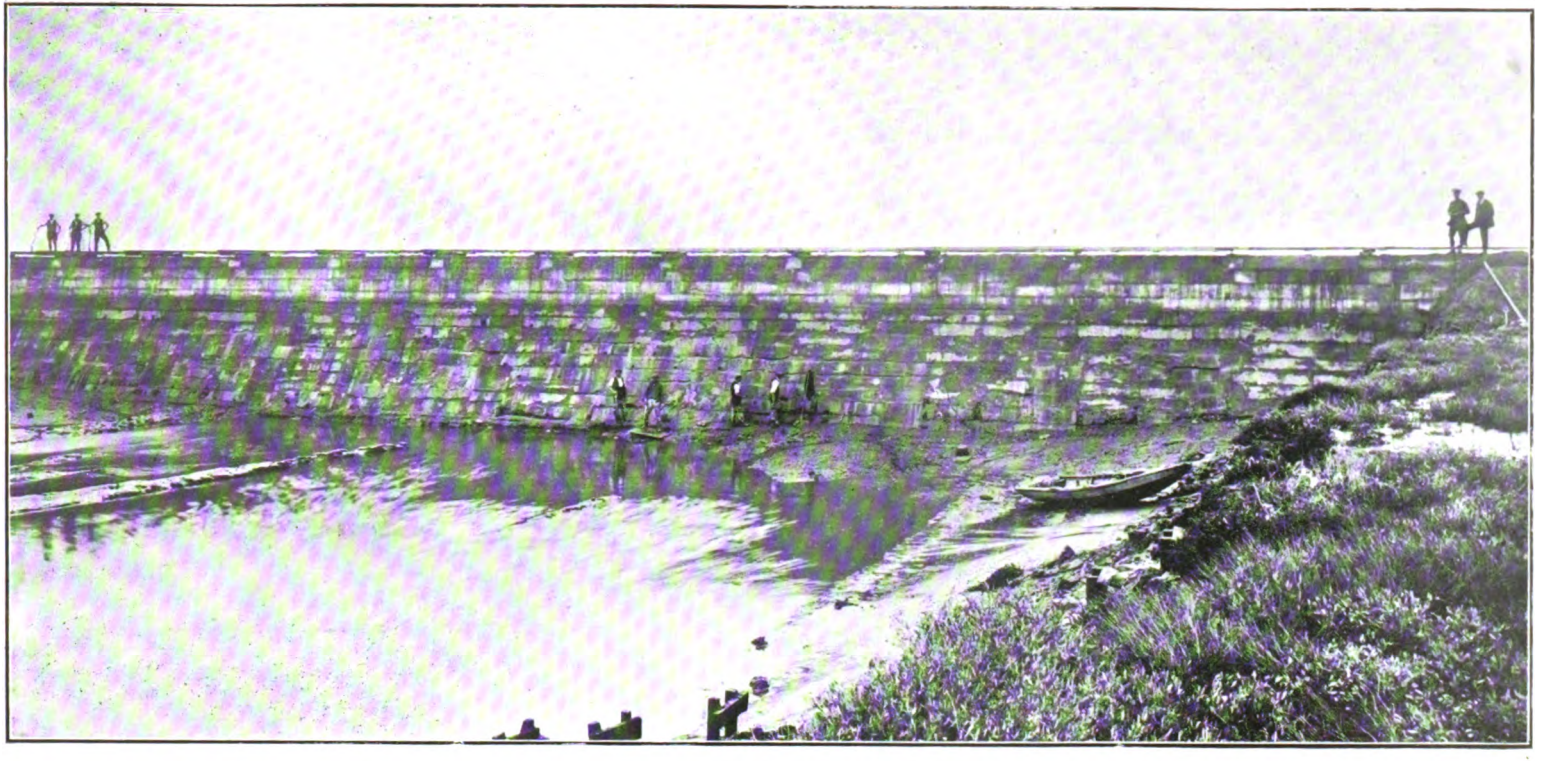

Fig. 9.

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could be landed at site by the same means considerably under schedule prices. (Barging material direct to site was out of the question, as loaded barges could only pass over the Maplin Sands on high spring tides.) Last, but not least, workmen were conveyed to and from work, and saved a wearisome trudge morning and evening.

The dams as constructed, or being constructed, are each of a different character. " C " was the first to be built, and is a dam pure and simple, which will, when " B " is completed, be loaded on one side only. The length of the concrete portion is 240 ft.

" D," which is described below in some detail, is really only a causeway, as the tide rises and falls on each side of it. It was, however, designed as a dam in case " A " dam should ever be built. Its primary function is to carry the road, but it also serves to stop the tide-race up and down the creek, with consequent erosion of the banks and sea walls. The length of this is 350 ft., of which nearly 300 are concrete.

" B," the largest dam of all, is still under construction, and will be closed by dropping shutters down between reinforced concrete piers, founded on a concrete floor, enclosed between two low pile lines.

" D " Dam.

The lay-out of the mixer station was so arranged that the Thames ballast could be run in trucks alongside the mixers and shovelled direct into the hoppers. A full day's supply was six or seven 10-ton trucks. At the same time a turn-out was laid so that a truck of cement (one day's supply) could be placed at the side of the mixers. This reduced carrying to a minimum.

A Decauville line, with a loop in front of the mixers, took the concrete in tip-wagons to the site of the dams. The simplest way of carrying this line over the creek was to build piers of pre-cast concrete blocks, which could be placed in position at low tide upon small concrete foundations. It would not have been safe to build these piers to the full height of the dam, owing to the resulting weight on the mud, and the moral certainty of their being overturned if any slight scour occurred. They were accordingly made only six to eight feet high, and were incorporated in the dam, as the latter rose. Care had to be taken to remove seaweed clinging to these piers before concrete was placed round them.

Fig. 2 shows the Decauville supported across the creek, and how 45-lb. rails were clipped together with steel sleepers to form the track without the use of girders. One intermediate sleeper between each pier would have been sufficient, but two were used for subsequent convenience in forming a pathway between the metals.

Piers were placed alternately 14 and 16 ft. centre to centre, as

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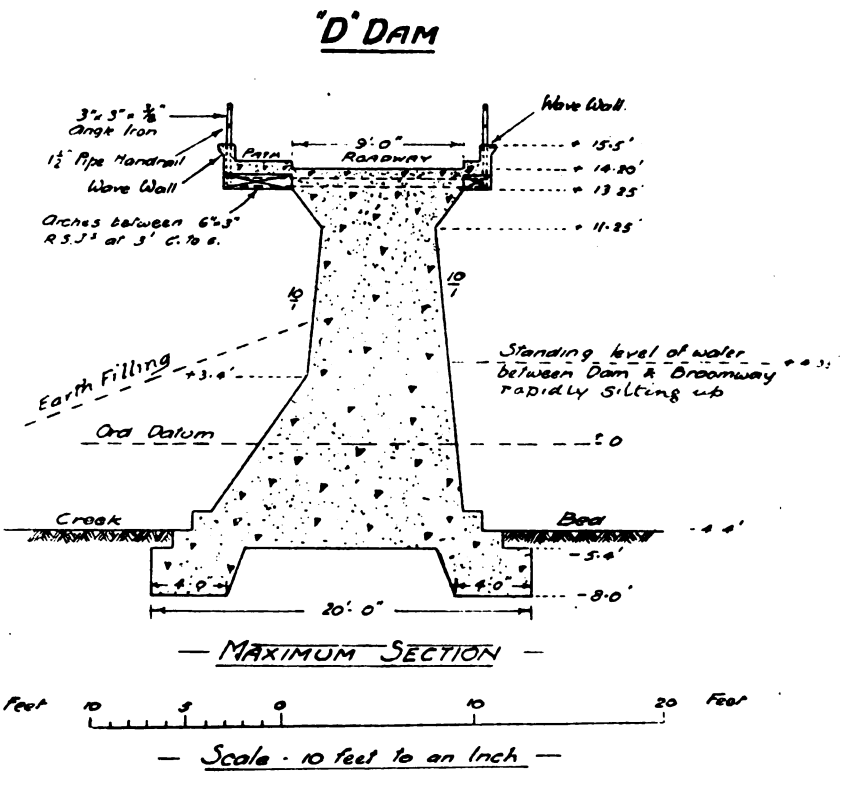
this suited both the 30-ft. rails available, and also the 14-ft. and 16-ft. piles, which were used for casings to the concrete.

This *Fig.* also shows the toe-walls being excavated to conform to the section of the dam, and the concrete being tipped from the Decauville immediately after the excavation. This was necessary, as the sides fell in under the slightest provocation. Shoring of stakes and old corrugated iron was resorted to where necessary.



At the end of each day's work a sandbag wall was built. This kept the concrete clean, could easily be removed, and left a good broken surface for the next day's concrete to key on to. There was no question here of laying concrete in layers of specified thickness. This would only have resulted in each layer being covered with mud by the incoming tide, or in the sides falling in before each section was complete. By bringing the toe-wall at once up to the level of the creek bed, it could be covered up with sailcloth and weighted down with rails, piles, sandbags, etc., so that the tide passed harmlessly over it.

Fig. 3 shows the last section of the landward toe-wall being excavated and the concrete standing by on the Decauville, ready to be tipped as soon as required.

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Between the toe-walls the mud was removed so as to expose the clay upon which to rest the body of the dam, and a levelling course was then constructed across the bed of the creek. As mentioned above, it was possible to divert the last of the ebb from one side of the creek to the other, so that one or two hours' concreting was generally possible before the tide returned. In neap tides, however, the tide sometimes did not recede far enough to permit of any work being done.

Fig. 4 shows the dam four courses above the levelling course, and the wooden profiles which were at first used to give the correct slopes. These profiles were really unsuitable as they were constantly being displaced by the tide. The same happened to wooden shuttering for the concrete, and it was found that no amount of weighting down with rails or piles would prevent this. As a result it was decided to use rails for the profiles, and steel piles for the shuttering, which could be wedged against the foot of the rail profiles, as shown in *Figs.* 4 and 6.

The piles were not stiff enough without one intermediate wiring to resist bulging under the weight of the concrete, but when so wired proved quite satisfactory.

Fig. 4 also shows the original Decauville and its piers protruding above the concrete, and how the rail profiles were used to form piers for the high-level line, when the lower one ceased to be useful.

At the level of the dam shown in this photo, the tide still ebbed over it from the Broomway even at low water, and the nearest bay to the camera of those over which water is flowing has been left at a lower level to form a spillway. This was sufficient for a short period on each tide to relieve all the other bays of water, and allowed them to be concreted dry.

The concreting of the spillways themselves took a certain amount of care. Shutters were placed on the water side and sacks of clay stuffed round them. By this means the rush of water was sufficiently checked to make the depositing of concrete possible. The difficulty of the water still flowing was got over, first by making the concrete 33 per cent. richer, and secondly by pushing the concrete forward from one side of the gap as each successive batch arrived from the mixer (at three-minute intervals), so that only one edge of it was subjected to the flow.

A certain amount of cement was of course lost, but no leaks were traceable to this cause. On only one occasion was there a failure to close a spillway at the first attempt, and this was caused by the tide returning an hour before it was due and catching the freshly-deposited concrete before it could be properly protected.

There is no doubt that by pushing concrete forward into water in this manner, instead of dropping it, the resulting mass can be made as satisfactory as if laid on dry land in the ordinary way.

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The method of protecting newly-deposited concrete from the incoming tide, and the force of the latter, can be seen in *Fig.* 5. Sailcloths are spread over the concrete and weighted down in position by rails, piles and sandbags. To the ends of the sailcloths (under water) are attached rails to keep them from being lifted, and they were made of sizes to fit the work.

Fig. 6 shows the dam still further advanced and above the level of the Broomway, so that there is no water to interfere with construction for several hours a day.

There can also be seen the high-level Decauville resting on the rail profiles; the sheet piling being used as casing for concrete; the method of wedging it against the foot of the rails; and the vertical chocks to which were attached the intermediate wirings.

Fig. 7 shows the corbel for the roadway; the cross girders to carry the footpath; and the concrete road over the dam nearly finished. The mass of earth against the dam needs a word of explanation. The lake between the dam and the Broomway is at present over 8 ft. deep, and nearly a mile long, but every tide brings with it quantities of sand in suspension, which is deposited in the lake.

In time, probably under a year, if one may judge by a similar occurrence at "C" dam, this sand will rise to the level of the Broomway. There will then be, against the southern face of the dam, several feet of semi-liquid mud, in place of water, with a very much higher specific gravity.

It is to meet the extra thrust, which this mud will impose, that about 3,000 cubic yards of earth have been provided on the landward side.

Fig. 8 shows the work practically completed, with wave-walls and railings. The cost of this dam, exclusive of wear and tear of machinery, was £5,200, as compared with the estimate of £8,025 for the original piling scheme, without roadway.

The amount of concrete placed was 2,500 cubic yards, and of earth, 3,500 cubic yards, including 500 placed on the seaward side as additional protection against infiltration.

The average number of men employed was 20, though in the early stages, when only two or three hours a day could be worked at low tide, as many as 40 could be accommodated. For the remainder of the day they were transferred to the road on Foulness.

The dam took a year to construct, but of this period about two months were lost through inclement weather, and the necessity for pushing on with the road to facilitate a W.D. housing scheme on Foulness, which is Government land.

No contractor was employed, the work being carried out by direct labour.

The proportions of concrete used were one bag of cement to

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¾ cub. yd. of Thames ballast for ordinary work, equivalent to 1 : 7½ when allowance is made for the shrinkage of ballast concrete on setting, and one bag of cement to ½ yd. ballast, or 1 : 5 for foundations and closing spillways. The roadway is of 1 : 4 concrete.

It may here be mentioned that cement is weighed by the makers into sacks to the nearest pound, resulting in far greater accuracy than can be obtained by measuring boxes, and the use of the latter always means wastage, particularly when there is a wind blowing. To minimize loss by wind even from sacks, these were always emptied into the mixer-hopper when it was only a quarter full, so that its sides might act as a wind-screen.

Mixers were placed in pairs, one ½ yd. and one ¾ yd., so that each strength of concrete could readily be mixed, and each mixer served as a stand-by to the other in case of a break-down. This was found to be a very necessary precaution with the second-hand plant employed, although it is only fair to say that the almost invariable cause of stoppage was the magneto, and not any mechanical defect. Cheap sparking plugs were a false economy ; it is essential to have a kind which can easily be taken adrift for cleaning the porcelains.

It was found that elevating hoppers were unnecessary, when ballast was unloaded from trucks. They were even a disadvantage, as being liable to break down, and at the best taking time to function.

Quick-setting cement was tried for this dam, but experience proved that, unless it was used within about ten days of manufacture, its quick-setting properties disappeared, and it then set more slowly than ordinary cement. This is no reflection on the quality of the cement, which was far above standard in tensile strength, but was due to the absence of dry storage accommodation.

Cement of all kinds was purchased by the barge-load of 100 tons or more, and took a week after manufacture to arrive on site. It was not practicable to lay it all in the few days remaining during which the quick-setting properties survived.

As very satisfactory results were obtained from ordinary cement when protected by sailcloths (as described above), the expense of providing suitable storage was not justified.

Salt water was used for concrete in this dam, and caused fifty per cent. slower setting, but on the other hand enabled work to be carried on regardless of frosts, during the winter months.

"C" Dam.

Fig. 9 shows "C" dam complete, except for the earth-backing. This dam was constructed on much the same principle as "D." The chief difference was that, in place of rail profiles, the correct slopes were given by setting pre-cast concrete blocks at 15-ft. centres on each face, and fixing the shuttering against them.

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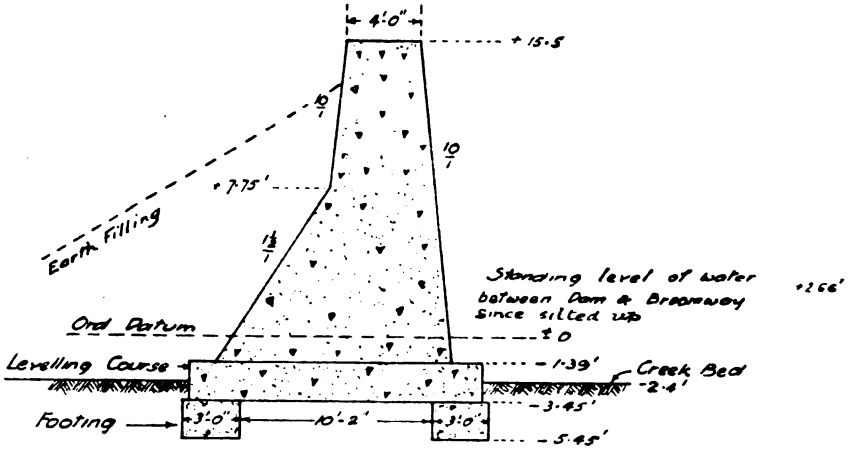
The blocks weighed 4 cwt. each, but were often displaced by the tides, and were not easy to handle under the Decauville. The latter was raised, course by course, 15 in., as the dam rose. Less trouble would have been experienced if the blocks had been made narrower in a direction at right angles to the face of the dam, so as to offer as little resistance as possible to the tide, but they had all been made before this necessity became apparent. In fact, their construction was the only work possible on this dam when the tide drove the men out of the creek; the road was not then available as an alternative occupation.

"C" DAM



— MAXIMUM SECTION —

The cost of this dam was approximately £3,200, including 1,730 cub. yds. of concrete, 3,000 cub. yds. of earth, and joining on to an adjacent earth dam over another branch of the creek. The concrete worked out at 32s. 6d., and the earthwork at 1s. 6d. per yd., but these figures do not include depreciation of machinery. The time taken, including the laying and dismantling of half a mile of broad-gauge railway to the site, and lay-out of the mixer arrangements, was four months' actual working time.

As in the case of "D" dam, all work was carried out by direct labour, which was at the outset unskilled in this class of construction.

The force of water rushing over these dams when partially completed invites consideration of the use of tides for the generation of power. The difficulty usually found is that turbines, however satisfactory they may be on a falling tide, can no longer function when the tide has turned and is rising against them.

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In this connection a suggestion made by one of the many visitors to the dams, whose name the writer has unfortunately forgotten, seems well worth putting on record.

The scheme consists in the provision of :—

(*a*) A high-level lake, to feed the turbines, filled from the sea at high tide through automatic lock gates which close as the tide falls, and impound the water in the lake. These lock gates will be familiar to those who know the fen country, as they are to be seen on most of the important "drains."

The lake must contain enough water to drive the turbines for over twelve hours between tide and tide, without its level dropping more than a foot or 18 inches.

(*b*) A low-level lake of sufficient size to receive the outfall from the turbines without its level rising more than a foot or so in the same period. This lake discharges into the sea every low tide through similar automatic lock gates at its lower end, and these close against the returning tide, leaving the lake once more at low-tide level.

The minimum head always available for driving the turbines would, under this scheme, be the difference between the lowest level of the upper lake and the highest level of the lower.

Both lakes must, of course, be measured in miles to be capable of serious power-station work, and it is essential to have separate connection with the sea for each lake. Both these conditions are admirably fulfilled by some of the oyster-bearing creeks of the East Coast, though it is doubtful if a minimum head of even 10 ft. could be ensured on neap tides.

Three dams would be required for each power station, the outer two to carry the line of lockgates, and the intermediate one to house the turbine. The two following diagrams will make this clear.

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REPORT ON THE WORK CARRIED OUT IN R.A.O.C. WORKSHOPS ON THE REPAIR OF WORN COMPONENTS BY ELECTRO-DEPOSITION.

By CAPTAIN J. P. MCLARE, B.SC., A.M.I.E.E., R.A.O.C.

THE principle of the electro-deposition of metals has been applied commercially for a very great number of years in such processes as electro-plating, " cold " galvanizing, electro-refining of metals and in electro-typing and copying. It was not, however, until during the war, when the difficulty of obtaining supplies of spare parts for the vast and widely differing collection of guns and carriages, aeroplane engines, M.T. vehicles, etc., became so very acute, that the idea was evolved (by, it is understood, the Royal Flying Corps) of utilizing this means for building up the worn parts and making them serviceable again.

Experiments were carried out in France, more or less simultaneously, in the Repair Shops of what was then the R.F.C., the R.A.S.C. and the R.A.O.C., and, though there was a great difference in the type of parts requiring treatment passing through the respective workshops of these three units, they all found that the process could be successfully and economically applied for the repairs of many parts hitherto scrapped on account of wear. Deposition plants were, therefore, gradually built up and, though they remained to a great extent in an experimental stage up to the cessation of hostilities, a great deal of work was done, and an enormous saving made by the number of parts put back into service.

It may be interesting here to record that the process being carried out in France became known at home, and an Electro-Metallurgical Committee was set up in connection with the Ministry of Munitions, mainly through the instrumentality of the Sheffield University, for further research into this and other subjects, and to improve the methods and apparatus in use. Amongst the experiments carried out under the auspices of this Committee was an endeavour to build up the " A " tube of a 12-in. howitzer which had been accidentally machined to too great a diameter. This experiment, which was performed at the Coventry Ordnance Works, was somewhat ambitious at this stage of development of the process, and was only partially successful. It sufficed to show, however, that repair by this method was quite a feasible proposition, even in the case of a large job of this description, and that success would come with further experience.

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At the end of the war the deposition plants in France were dismantled when the workshops, with which they were associated, were broken up, and the personnel employed, which was never very great numerically, was dispersed. A good deal of knowledge and experience gained was therefore lost, as apparently no extensive records were made at the time of the procedure adopted by the different units concerned; and later, when it was thought desirable to have a consolidated record of the process for use in possible future emergencies, it was necessary to collect information from various sources and to cover, by experiment, a good deal of old ground. Fortunately, some of the R.A.S.C. officers concerned have written a paper on their process and various experimenters have since published results of their researches which have assisted in advancing knowledge of this method of repair, and at least one firm (originated by members of the staff of the R.A.O.C. deposition plant at Havre) is applying the process commercially, so that it has by no means been allowed to die.

In the R.A.O.C. Workshop at Chilwell, a small plant has been arranged and efforts have been made from time to time to develop the process with the primary object of having in the Corps the necessary knowledge available in the event of war to lay down and work a plant in the field for the repair of various valuable gun and carriage parts. So far, owing to the comparatively small wear which occurs in Ordnance in peace time, and the number of new spare parts available to replace any which do become unserviceable, there has not been any scope for a deposition plant in anything more than an experimental way.

A few practical jobs, however, have been done of which descriptions are given later. It is proposed first of all to describe briefly the development of the process and indicate the stage to which it has now been brought.

DEVELOPMENT OF THE PROCESS.

It is understood that the R.F.C. initiated the process by depositing copper upon various engine parts to make up wear and to enable standard spares, such as ball and roller bearings, to be refitted to them. The deposition of this metal does not present any great difficulty, for, after cleaning the job and giving it a preliminary coating of copper in a cyanide solution, almost any desired thickness can be built up in an acid sulphate bath. The usefulness of copper, however, for this class of repair work is very limited, as it can hardly be applied to form an actual bearing surface, on account of its comparatively high coefficient of friction and its liability to "seize," and even when used only as a "packing" to restore parts to their original plan size, it is, on account of its comparative softness and ductility, liable to extrude, and looseness of fit soon redevelops.

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Very hard electrolytic deposits of copper can, however, be obtained by employing suitable solutions and current densities, so that the problem of extrusion can be eliminated with due care, and therefore, considering the ease and rapidity with which copper can be deposited in comparison to iron and nickel, its usefulness in an emergency for certain classes of work is not to be ignored.

The process of repair by electro-deposition, having thus been initiated, the next step was to endeavour to deposit some other metal of more general utility than copper; a metal suitable for building up an actual rubbing bearing surface or ball race. It was known that practically all the elemental metals used for engineering purposes, and even some simple alloys such as brass, could be deposited electrolytically from solutions of their respective salts, but there is a wide divergence in the ease with which the different deposits can be obtained, and also in the nature and physical properties of the deposits. However, as the use of nickel for electro-plating purposes, and of iron for electro-typing, was universal, these two metals suggested themselves as being most likely to satisfy requirements. Development thus proceeded on these lines, iron being used chiefly by the R.F.C. and R.A.S.C. while the R.A.O.C. in addition accomplished great things with deposition of nickel.

In the early stages it was found impossible to obtain sound and adherent thick deposits of iron upon the basis metal (usually steel), as the preliminary cleaning process had not then been perfected. The cleaning so far was done on the lines of that usual in the electro-plating industry, and consisted of removal of grease or oil by petrol, boiling in caustic soda solution, scouring and finishing in an acid dip. Such preparatory treatment is suitable when very thin deposits only are required, as in providing articles with an ornamental or protective coating, but for the thick deposits now required it did not give a sufficiently high degree of adhesion, and as the deposition continued, it was unable to withstand the tension which is set up in an electrolytic deposit, and consequently "peeling off" ensued.

The practice was therefore adopted of giving the job, after cleaning, a preliminary coating of copper in a cyanide bath. The adhesion of this coating was fairly sound, as the cyanide solution itself has certain cleansing properties, being able to dissolve any slight films of oxide which may exist on the surface of the work, and in addition the evolution of gas at the cathode tends to drive off extraneous matter. Having received this coating of copper, which took only two or three minutes to effect, the job was washed, and without giving it time to dry and oxidize, was transferred to the iron depositing bath. In this it was found possible to put on a thickness of about ·003 inches without risk of peeling off of the deposit, and when sufficient time had elapsed to give this thickness, the job was removed, washed, and put back in the cyanide bath for a further

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deposit of copper. This "sandwich" system was repeated until the total thickness of deposit required for the repair had been put on.

This system of building up enabled a fairly thick deposit to be made, but the adhesion to the basis metal and between the various layers left much to be desired, and more often than not, the deposit stripped off while being machined, or if not then, shortly after the particular repaired fitting had been put back into use. There were the further disadvantages that these deposits varied considerably in hardness, and as they were not capable of being heat-treated, they were of little use in cases where a hardened surface was necessary.

In order to obtain a greater degree of adhesion and to eliminate the necessity for copper coatings, attention was directed towards improving the cleaning process, as it was recognized that the secret of success lay in this direction. The aim was to obtain an absolute "chemically clean" surface on the portion to be built up, upon which deposition could commence the moment the job was placed in the bath. It was discovered after a time that the substitution, for the acid dip, of an electrolytic acid bath in which the job was placed as anode, gave good results; further improvement was subsequently made by the introduction, in addition, of electrolytic alkaline baths, and after experiment had decided the compositions of the solutions of these baths for consistent results, the cleaning problem was more or less solved.

With this improved cleaning process it was found possible to put fairly thick deposits of iron direct on to the basis metal and the adhesion was so good that heat treatment could be given and articles case-hardened when required. Such heat treatment, so far from loosening the deposit or impairing the adhesion, greatly improved matters, as micro-examination revealed the fact that the deposit then became thoroughly merged into the basis metal and the previous clear dividing-line between the two disappeared.

From this point, development was sought in the direction of gaining knowledge of depositing solutions and their working, and this involved considerable experiment and research.

The most suitable substance from which to make the iron-depositing electrolyte proved to be ferrous ammonium sulphate. A dilute neutral solution was eventually adopted as being that which apparently gave the most reliable and consistent results, and in order to prevent pitting of the deposit by the clinging of hydrogen bubbles to the work, and to keep it in contact with electrolyte of uniform iron content, a very efficient system of agitation of the electrolyte was devised as follows:—

The anode was made of soft Swedish iron wire, in the form of a cylindrical cage of sufficient size for the particular work in hand, and which it surrounded. (*Fig.* 1.) Fitted to the inside of the cage were two or more celluloid rings slightly cone-shaped. The

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whole anode was suspended from a rocker arm, which, when set in motion, gave it a slow up-and-down movement, and thus, by the pumping action of the celluloid rings, the whole volume of liquid was kept in gentle motion.

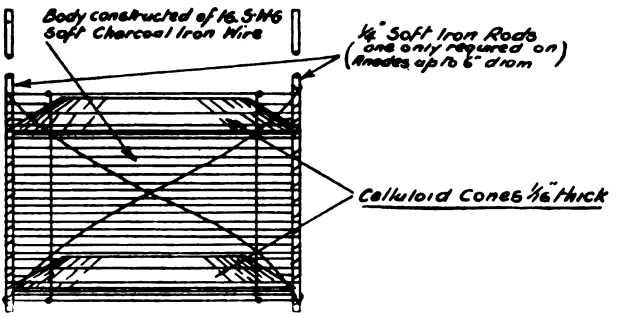
Body constructed of 16 S.W.G
Soft Charcoal Iron Wire
¼" Soft Iron Rods
(one only required on
Anodes up to 6" diam)
Celluloid Cones 1/16" Thick

FIG. 1.

The employment of the dilute neutral electrolyte, while giving fairly good results in the shape of a finely crystalline and firmly adherent deposit of considerable hardness, had the disadvantage that it was only possible to use a current density of at most 5 amperes per sq. ft. of cathode surface, giving a rate of deposition of only ·00027 in. of thickness per hour, thus making the process a very slow one. For this reason, and also on account of the fact that very great care had to be exercised in the control and the manipulation of the ferrous ammonium sulphate electrolyte, by reason of its tendency to oxidize and form insoluble ferric salts which adversely affect deposition, the R.A.O.C. personnel engaged in this work decided to deal more particularly with the deposition of nickel. A concentrated solution of nickel salts could be employed in this case, making possible a rate of deposition of ·001 in. thickness per hour, and in addition the oxidization troubles did not arise.

The adhesion of the nickel to the basis metal was, provided that the preliminary cleaning process had been properly performed, all that could be desired; and as electrolytic deposits of this metal are extremely hard, it being possible to obtain those having Brinell hardness numbers of well over 400, it was argued that nickel would meet all requirements in connection with the repairs to be dealt with, with perhaps the exception of parts which required a hardened and tempered surface, or others which may be required to be subjected to high temperatures, as, for example, cylinders, pistons and gudgeon pins of internal-combustion engines. Nickel deposits, in addition to their hardness, possess the advantage of being rust-proof, and capable of taking a high degree of polish, forming an admirable wearing surface.

It was still thought necessary with the nickel solutions to employ

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means of agitation for the removal of hydrogen bubbles, and a system of rocking-arms was provided. In this case, however, the anode remained stationary in the bath while the article being treated was moved to and fro, and in some instances a form of brush was immersed in the solution which rubbed across the work as it moved, thus ensuring the removal of bubbles.

In the deposition of both iron and nickel, each job, except very small parts, which were dealt with in bulk, was treated in a separate bath which was made up according to the requirements of the particular work. Whenever possible, the whole job was put into the bath, those portions of it upon which no deposit was required having been previously "stopped off" by a suitable wax composition. In many cases, however, a comparatively small portion of an article too large to be put into a bath was required to be repaired, and then it became necessary to build up a containing vessel round the part. Such containing vessels were usually made of sheet-iron waxed inside for purposes of insulation, and after being arranged in position, were made water-tight by running more of the wax composition round the joints.

The aforegoing is a brief summary of the progress made from the initiation of the progress up to the end of the war. Much useful work had been done, even though a small percentage of failures occurred, many of which could be attributed to faulty cleaning or manipulation of the depositing baths, while others may have sprung from insufficient knowledge of the control required to keep the chemical compositions of the various electrolytes within the limit of their proportions for proper and efficient working.

The drawbacks to the process, evident at this stage, were :—

1. Its extreme slowness, especially in the case of deposition of iron.
2. The lack of consistency in the physical nature of the deposits.
3. The complications, introduced into the apparatus, required by the necessity for agitation of the electrolytes.
4. The great care necessary to ensure success, and the skilled personnel required to carry out the work.

On the other hand, it was the only known means of making a real repair of many a costly article, and the cost of the repair was trifling in proportion to that of a new one. In addition to this, salvage of worn parts in the field on an extensive scale would, in war time, lessen the strain in the industrial establishments at home, ease the traffic problem, and effect a saving in time, labour and material, in many directions; so that, in spite of the difficulties associated with it, the process was one which fully justified itself, and the field for further research opened up was one which gave every promise of providing the engineering world with a most useful and efficient "putting on" tool.

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Outline of Process.

The various stages of the process as now carried out are :—

1. Removal of oil or grease, if present, from articles by petrol.
2. Cleaning in boiling alkaline electrolytic bath ; this also removes any rusting which may be present.
3. Washing in warm clean water.
4. " Stopping off " of such parts as may be necessary.
5. Cleaning in cold alkaline electrolytic bath.
6. Washing in cold clean water.
7. " Anodic " cleaning in acid bath.
8. Washing in cold clean water.
9. Deposition.

In many cases where the parts to be treated are not greasy, oily, or rusty, stages 1 to 3 may be omitted. Further modifications may also be necessary in cases where the bath has to be built round the work.

The lay-out of the plant should be so arranged that the work may pass through the various baths, etc., in progression. The secret of success, so far as good adhesion goes, lies in having the job in the necessary condition of absolute cleanliness, when it is placed in the depositing bath, and that deposition must commence immediately. To this end it is essential that no time should be lost in washing the work after leaving the acid cleaning bath, and transferring it to that for depositing. The washing must certainly be efficiently carried out, but the film of water covering the cleansed part must not be allowed to dry, for, should this occur, oxidization would take place—very slight, it is true, but sufficient to prevent good adhesion.

Alkaline Cleaning Bath, Hot.

The composition of the electrolyte in this bath is :—

Commercial caustic soda	1 lb.	per gallon of water.
,, washing soda	½ lb.	
,, sodium cyanide ...	1 oz.	

It is contained in a welded iron or mild steel tank of suitable size and shape for the type of articles to be dealt with. The temperature should be just under boiling point, and the heating can be effected either by the external application of heat to the tank by gas or oil stove, but more preferably, for reasons of control, by a steam coil inside the bottom of the tank. The coil would require an insulated joint in order to lessen the risk of short circuits and to obviate leakage and wastage of current, and for the same reason the tank itself should be mounted on a wooden stand or otherwise suitably insulated.

The metal of which the tank is made can be connected to the

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positive current supply and serve as anode. It is better, however, to have two iron plates suspended in the bath for this purpose, as the cleaning off of the sludge and scale which collects can then be more readily effected and, in addition, the distance between the work and the anodes can be adjusted to meet individual requirements.

The article to be cleaned is suspended in the bath as cathode, and a current density of about 100 amperes per sq. ft. of cathode surface is required. The time required for treatment is from 3 to 10 minutes, depending upon the state of greasiness or rustiness of the part to be cleaned. On removal, the article should present a dark grey appearance and will probably be coated with a slight powdery deposit, which, however, disappears in the subsequent washing operations.

This hot bath was not employed in the process in France, it being the practice then, instead, to boil the articles for several hours in a strong solution of caustic soda. It may be said, therefore, that a considerable improvement is effected by the introduction of this electrolytic method beside saving a great deal of time.

STOPPING-OFF.

After washing in warm water, the article is allowed to cool, but, while still slightly warm and dry, the "stopping-off" compound is applied to such parts as require to be insulated. The part upon which the deposit is required should be wetted with a clean damp cloth; this prevents the sticking of any overlapping portion of the compound, which, when "set," can be neatly trimmed up along its edges with a knife, and the surplus, being on a dampened surface, will peel off readily.

The stopping-off compound, which can be applied either by brush or by dipping, as may be most convenient, is usually a wax composition, and its preparation requires some care. It should set fairly hard, but not be brittle and liable to flake off. It should not be affected by the chemicals used on the process. Beeswax, for example, is slightly affected by strong alkali, but a small proportion of it mixed with other wax forms quite a good compound.

Compounds made up as follows have been found satisfactory:—

(*a*)	Paraffin wax	93%
	Carnauba wax	5%
	Boiled linseed oil	2%
(*b*)	Paraffin wax	80%
	Beeswax	20%
(*c*)	Bitumen	60%
	Paraffin wax	40%

A compound of guttapercha and paraffin wax has lately been evolved by another experimenter, and this appears to be a very good one indeed.

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Alkaline Cleaning Bath, Cold.

This is made up and used in the same way as the hot bath, but it is used at a normal room temperature. Its function is to provide a means of removal of dirt and grease from the work after "stopping-off" has been done. This type of cleaning is, of course, carried out much more quickly and efficiently in the hot bath, but a stopping-off composition has not yet been evolved which will remain solid at the temperature required. If, however, the job has already passed through the hot bath and care has been taken subsequently to keep the surface clean and out of contact with anything from which it could pick up matter of an oily nature, (it should not, for instance, be handled) a few minutes in this cold bath will suffice; if not, it will be necessary to allow 20 minutes to half an hour to obtain the desired result.

Acid Cleaning Bath.

This is contained in a suitably-sized lead-lined vat, and the electrolyte made up in the following proportion:—

Concentrated commercial sulphuric acid ...	2¼ lbs.
Water	1 gallon

It was customary, in the R.A.O.C. plant at Havre, to add a small proportion of copper sulphate in making up this bath, the theory being that it was necessary to have some salt present of a metal electro-positive to iron, to achieve the desired result. It is not, however, thought that this addition does materially affect the working of the bath, the main factor in successful cleaning being to obtain a vigorous evolution of gas by employment of a heavy current density of at least 200 amperes per sq. ft.

A suitable type of reversing switch is required in the circuit of this bath, one lead from it being attached to the lead lining of the tank, and the other to the bar from which the article to be cleaned is suspended in the electrolyte.

Operation.—The article should be well rinsed in clean cold water, after being through the cold alkaline bath, and be put into the acid bath without loss of time. The current should be switched on, making the article the anode. A black film forms on it immediately and very little gas is formed; in about 30 seconds or so, however, this film will be observed to break away, and a free evolution of oxygen takes place. Allow this gassing to continue for about 20 seconds and then quickly remove the article, the surface of which will be found to have a clean grey matt appearance. Wash off the acid as rapidly as possible and transfer at once to the depositing tank.

Ordinary mild steel will be found in most cases to respond to this cleaning treatment very readily, provided the necessary current

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density is applied. In some instances, however, and especially with the harder steels, it will be found that the black film does not break away as described, or does so only partially. The current in this event should be reversed for about a minute, making the article the cathode; an evolution of hydrogen then takes place which assists in disintegrating the clinging film, and on again changing over the switch the cleaning will be accomplished.

In order to prolong the "life" of the electrolyte, anodic cleaning should not be continued more than is necessary, as ferrous sulphate is gradually formed in the solution, and when this reaches a certain limit the bath becomes inoperative and must be renewed.

DEPOSITION OF IRON.

It has previously been mentioned that the process, as carried out in France, was very slow on account of the use of dilute solutions containing about 12 ozs. per gallon of ferrous ammonium sulphate and the consequent necessity for employing very low current densities. Experiments were therefore made, with a view to discovering, if possible, some means of using more concentrated solutions, the current densities being increased in proportion to the degree of concentration.

It was found that medium-strength solutions, containing from 1 lb. to 2¾ lbs. of the salt per gallon, whether used slightly alkaline, neutral or slightly acid, gave deposits which were very much pitted and had a sponge-like appearance; they were, too, very brittle and useless for all practical purposes. With strongly-concentrated solutions, however, containing from 3 to 3¾ lbs. per gallon it was found possible to obtain excellent deposits of any thickness, entirely free from pitting; and as a current density of 18 to 20 amperes per sq. ft. could be employed without any necessity for continuous agitation of the electrolyte, the rate of deposition was increased approximately fourfold.

The concentrated solution should be neutral, or only very slightly acid, to obtain deposits of reasonable hardness: excessive acidity makes the deposit hard and brittle, while alkalinity tends to produce pitting. Other points in connection with the working of the concentrated solution are:—

1. It is preferable to do as much work as possible in a large vat, for the following reasons:—

(*a*) The acidity and the iron content of the solution are apt to change continually, and periodic examination and rectification is necessary. With a large bulk of liquid the change is less rapid than in the case of a small quantity, and control can therefore be more efficiently exercised.

In this connection it may be mentioned that the type

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and quality of the anodes used have a great bearing on this point. Hard anodes tend to weaken the iron content, and increase acidity. The most satisfactory type were found to be those made from very soft Swedish iron wire, wound either into the form of a cylinder or flat grids, as may be most convenient. With these soft anodes the iron content was found to remain practically constant, but the solution gradually became neutral and even slightly alkaline. This matter, however, is easily remedied by the addition, from time to time, of small quantities of sulphuric acid.

(*b*) The larger bulk requires less frequent decantation to eliminate the insoluble products of oxidization.

(*c*) An occasional stirring is all that is required, whereas with a small quantity of liquid, a more or less continuous agitation is necessary to obtain good deposits.

2. When the use of a small quantity of electrolyte is unavoidable, as in the case where the containing vessel has to be built round the work, a careful control must be exercised as regards iron content and acidity, some form of agitation should be used if practicable, and it is advisable to use a lower current density than in the larger baths, not more than 15 amperes per sq. ft. at most.

3. When deposition is continued overnight and attendance is not available to administer the occasional stirring to the electrolyte, it is advisable to reduce the current density during these still hours to about 12 amperes per sq. ft. The reason for this is that the electrolyte in the lower portion of the bath becomes more dense than that above it, and consequently the deposit goes on unevenly, and the lower portion will probably be hard and brittle.

4. The temperature of the electrolyte has a considerable bearing on the quality of the deposit, those produced at a too low temperature being hard and brittle. It is, therefore, essential to keep the temperature of the room in which the deposition is being carried out fairly constant, the minimum being about 18° C.

5. The anodes should entirely surround the cathodes and have a total area, if possible, at least four times as great as the latter. They should be taken from the bath periodically and the black slime which settles on them removed by scrubbing and washing.

6. Loss of liquid by evaporation should be made up by the addition of distilled water. If the solution is allowed to become too concentrated, the salt will crystallize out on the sides of the vat and on the anodes.

7. The current should be maintained throughout the whole period of deposition, as interruptions tend to produce a deposit consisting of badly adherent layers.

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DEPOSITION OF NICKEL.

This presents much less difficulty than that of iron, for, as has previously been mentioned, the formation of oxides does not occur in the electrolyte in the same troublesome manner. Further, the composition changes very slowly, if at all, as the bath, when properly arranged, has practically equal cathode and anode efficiencies and, therefore, control becomes a very simple matter, all that is required being the addition, from time to time, of distilled water to make up any loss due to evaporation. With a suitable nickel electrolyte it is sufficient to gauge the degree of acidity by means of litmus, whereas a much more accurate determination of the quantity of free acid is essential in the case of that for the deposition of iron to ensure good results. In the latter it is necessary to carry out periodical analysis of the electrolyte by titration with standard solutions.

There are many formulæ for the composition of nickel electrolytes, each having its own bearing on the quality and nature of the deposit produced; the particular one adopted would depend upon the purpose in view. For the thick deposits required in the case of building up worn parts, the following gives satisfactory results :—

Nickel sulphate	... ...	2 lbs.
Nickel chloride	... ...	$3\frac{1}{4}$ ozs.
Boric acid ...	... ...	$4\frac{3}{4}$ ozs.

per gallon of distilled water.

A current density of 20 amperes per sq. ft. of cathode surface can be employed at normal room temperatures, giving a rate of deposition of approximately ·001 inches of thickness per hour. As in the case of iron, good deposits, free from pitting, can be obtained without the necessity for agitation, when a sufficiently large bulk of liquid can be accommodated around the job.

TYPES OF WORK DONE.

Repair of Worn Axle of Railway Crane.

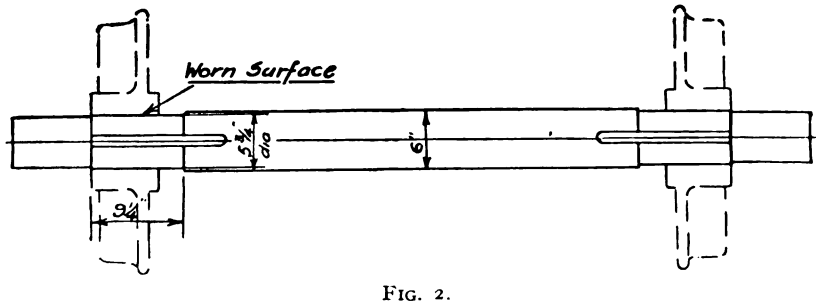

FIG. 2.

Continual jolting had caused one wheel to become loose in the axle, and it was found that approximately one-tenth of an inch of metal would have to be deposited on the diameter over this portion to enable it to be turned up to size again. It was decided to put on

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an iron deposit, but as the job was too large to be put into any of the vats available, a vessel was built around the part, as shown in *Fig.* 3, the base being of wood and the side a cylinder of soft iron sheet, the joints being made tight with paraffin wax.

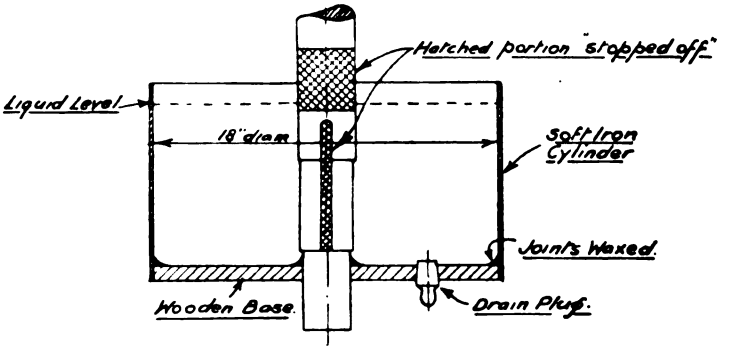

FIG. 3.

The hot alkaline cleaning treatment was carried out in a large "Derusting" tank, and after applying the "stopping-off" composition to the keyway and other portions as required, the axle was fixed up vertically and the smaller vessel assembled in position.

The cold alkaline treatment was then carried out, the iron of the containing vessel being made the anode. The liquid was then run off, the job washed with cold water, and the vessel filled up with the acid solution. An attempt to carry out the acid cleaning by using the side of the vessel as cathode was not successful, so a sheet of lead, bent to shape, was introduced to serve this purpose, with fairly satisfactory results. As soon as this operation was effected, the acid was quickly run off, the job washed, and a concentrated solution of ferrous ammonium sulphate poured in, the accumulators for supplying the current being connected meanwhile so that deposition would commence at once, the iron of the containing cylinder being used as anode.

A current density of 15 amperes per sq. ft. was employed for 65 hours without agitation of the electrolyte beyond an occasional stirring. It was found necessary to make small additions of sulphuric acid about every 12 hours to maintain the required degree of acidity, but the iron content remained practically constant.

Result.—The deposit was of the required thickness, fairly hard and free from pitting, firmly adherent except at the lower edge. This slight defect was due probably to this portion being in contact with the sludge which settled at the bottom of the vessel, and could have been obviated by allowing more space for the settlement of this sludge.

The deposit was turned up on a lathe and the wheel refitted, and the axle was in daily use for 18 months without showing any signs of wear.

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REPAIR OF PLANING MACHINE BLOCK.

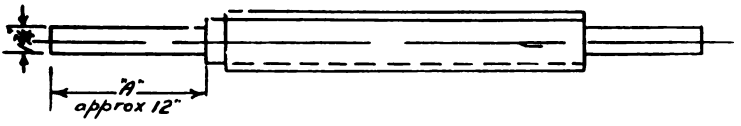

FIG. 4.

The portion of the cutter block shaft " A " upon which two ball-bearings fit had been turned down in error to ·1 in. under plan size diameter. An iron deposit was put on, in a large vat, and the job was quite successful, the deposit being hard and firmly adherent, and it ground up to a very fine smooth surface entirely free of pitting.

REPAIR OF WAGON AXLES.

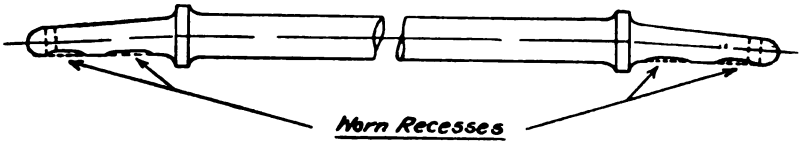

FIG. 5.

These axles are worn very deeply and unevenly at either end in two places, as shown in *Fig.* 5. It was decided to expedite the repair by filling up the deeper portion of the worn recesses by a copper deposit and then, after turning the whole to an even-tapered surface, to finish off with a nickel deposit of about ·05 in. in thickness.

The first layer of copper was deposited in a cyanide bath and the remainder in an acid copper sulphate bath at the rate of about ·0025 in. per hour.

The nickel was then applied, after turning up and repeating the cleaning process, and a fine smooth bearing-surface obtained. The nickel deposit is much harder than the original steel of the axle, so it is anticipated that the repair should give a considerably longer second life to the article.

Other small articles, such as gudgeon pins, tappet valves, etc., for I.C. engines, have been repaired by iron deposition, and it has been found that the wearing qualities of the deposit are excellent and that it remains firmly adherent even though it be subject to high temperatures during use.

DEPOSITION OF SILVER AND LEAD ON RUBBER RINGS FOR PACKINGS FOR GUN MOUNTINGS.

In addition to the work carried out by the R.A.O.C. at Chilwell on the repair of worn components by the deposition of iron and nickel, experiments were made with a view to evolving a resilient

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"metallic" packing to replace the textile packings at present used in the glands and stuffing boxes of buffers and recuperators of gun and howitzer mountings. The disadvantage of the present type of packing is that it tends to cause pitting of the finely-polished surfaces of the rods and cylinders, and when this occurs, the parts become unserviceable.

The idea was therefore conceived of enclosing rubber rings within a coating of metal of suitable thickness. Such a packing would be very resilient, forming a tight joint and yet would possess a metallic bearing-surface having no corrosive effect on the rods or cylinders. In addition, there would be less friction at the joint, less wear, and, consequently, less frequent renewals would be necessary.

In a packing of this description it would be necessary to completely enclose the rubber in order to protect it from the disintegrating action of the oil used in the buffers and recuperators, and it was thought, therefore, that the metallic coating could most conveniently be applied by electro-deposition. Silver and lead were selected as being the most suitable metals for the purpose, and suitable baths were therefore made for their deposition.

The first problem to be solved was that of obtaining a suitable conducting surface on the rubber; various expedients were adopted such as :—

1. Rubbing fine plumbago into the surface of the rubber.
2. Coating with a paint made up with plumbago.
3. Coating with a paint made up with bronze powder and amyl acetate.
4. Winding very thin copper tape on the rings to completely cover the surface.
5. Dipping in solutions of phosphorus in carbon bisulphide and silver nitrate in water.

None of these methods gave altogether satisfactory results, so the production of a film of silver sulphide (which is a fairly good conductor) on the surface of the rubber, was made by dipping the ring in a hot strong solution of silver nitrate and, when dry, treating it with sulphuretted hydrogen. This method achieved the desired result and good smooth deposits were made upon the conducting surface thus formed.

Having prepared the rubber in this manner, a piece of very fine copper wire was placed round the periphery of the ring, which was then suspended in the depositing bath. As soon as a film of lead had been formed over the whole surface, the ring was taken from the bath and the copper wire carefully removed. The ring was then replaced in the bath until the required thickness of deposit had been obtained, being suspended now by means of a wire hook, making a somewhat loose contact with the lead.

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COMPOSITION OF LEAD BATH.

The electrolyte used was a fluoborate solution of the following composition :—

Basic lead carbonate	20 oz.	Per gallon of solution.
50% hydrofluoric acid	32 ,,	
Boric acid	16 ,,	

Small quantities of glue were added from time to time, as this was found to assist materially in the production of smooth deposits.

A current density of 20 amperes per sq. ft. was used and a rate of deposition of approximately ·003 in. per hour was obtained.

The thicknesses of the deposits given varied from a few thousandths of an inch up to ·1 in.

While it was not found that there was any distortion of the ring whilst undergoing deposition, it was noticed that in the case of the heavier deposits, the thickness was uneven in places. This matter, however, was easily remedied by a slight skimming up on a lathe, and the true circular shape required was thus obtained.

Some of the lead-coated rings, after being turned up, were silver-plated, this operation being carried out, after anodic cleaning in an acid bath, in a commercial cyanide electrolyte.

The packings when tested in an 18-pdr. gun-carriage were found to be extraordinarily resilient, and made a tight joint, as anticipated. The lead and silver coatings, however, invariably split on the sides circumferentially under pressure, allowing access of oil to the rubber, and further experiments are required to evolve a design of packing and supporting rings to overcome this trouble.

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SOME THOUGHTS ON THE GROWTH OF MODERN FIELD DEFENCES.

By COLONEL G. C. WILLIAMS, C.M.G., D.S.O.

So keen are we to teach and maintain the offensive spirit that the study of defence is sometimes, even in these enlightened days, almost unpopular. Yet in every other game we know that we must learn both attack and defence before we can become proficient players.

Napoleon's opinion on the use of fieldworks was :—" Those who prescribe the use of defensive lines and the assistance which the science of the engineer can afford, deprive themselves gratuitously of an auxiliary, which is never injurious, almost always useful and often indispensable. It must be admitted at the same time, that the principles of field fortification require improvement."

The rôle to be played by field defences is to gain time, and to husband men, until the assumption of the offensive. And moreover, as the ultimate object is to attack, the defence must be able to develop the full possibilities for the counter-stroke. And so we have in the defence a most useful servant ; but one which needs knowing and which needs careful watching, or he will become the master of us How easy a thing it is to become tied to trenches was only too apparent in the Great War. And this danger became such a bugbear to many a commander, that some distrusted trenches altogether and sought, not to learn their real uses, but for ever to avoid them. But, after all, the trenches are for the troops and not the troops for the trenches. Nor, of course, do mere trenches manned by troops constitute defence at all. Trenches and field defences, like armour, are an aid to an active defender ; and if used as such, they can never become a danger.

Since Napoleon wrote the maxim which I have just quoted, the art of field fortification has certainly improved. But I do not know that we can pride ourselves on having made all the improvements. They seem rather to have forced themselves upon us : and it has come about in this way.

The pre-war conception of a defensive position was clearly laid down as consisting of advanced troops to delay the enemy's advance, a main position to stop him and reserves behind whose duty was counter-attack.

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In the Great War when the battle of the Marne became stabilized, the assaulting waves, as must happen on some part of the front in every big battle, found themselves dug in on a line closely watching the enemy. Then occurred a curiously inexplicable thing: as measures for defence were taken in hand, the pre-war conception was not practised; but so arresting were those front lines of fighters, that they assumed undue importance in the eyes of all. And the form of defence evolved was designed to maintain those sacred lines intact, to the exclusion of all other considerations. It may have been pride not to cede an inch of territory, or it may have been the desire not to give up anything that had cost so much to win. But there it was—the front lines became the main lines of resistance.

And what splendid and easy targets those front lines were! Naturally, every form of devilry was turned upon them. And every inventor thought that he only had to find something to destroy them in order to win the war; and so trench-mortars, "pigs," "babies," "pine-apples," hand-grenades, mines, took a heavy toll of those closely-packed and precious lines.

It was this very drastic treatment, intensified by a big increase in artillery, which could so quickly turn a spotless front-line trench into a pock-marked wilderness of broken timber, twisted iron and torn sandbags, that forced the stubborn opponents at last to live farther apart.

And so defence in depth made itself known.

So you see it was no sudden invention, no great brain-wave—this defence in depth.

Other things, too, were helping to evolve the modern system of defence as we know it now. The new power of automatic weapons was proving the value of the machine-gun to produce fire-power and to reduce man-power in defence. And so the defence in depth was laid out primarily as a machine-gun defence. Machine-guns were grouped to cover the main lines of approach, while the infantry concealed themselves in places from which they could best employ their most successful rôle, *viz.*, the counter-attack.

Then, while the machine-gun and the infantry were content with concealed positions, the growing importance and longer ranges of the big gun demanded good observation; and so observation, safe observation, became the keynote of the modern defensive position. Consider the advantages of Hill 70, Aubers Ridge, Vimy Ridge, Lorette Ridge, Chemin des Dames, Messines Ridge, Passchendaele Ridge, Mount Kemmel; and these were not all: it was always the high ground that was the bone of contention. Further inventions came to complicate the already intricate systems of defence. Increase in enemy artillery called for greater and greater depth, and further removal of the battle zone from the outposts. Aerial observation called for more complete concealment than had been

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needed against ground observation; and so the feminine art of camouflage and deception was called in to aid the field engineer.

The tank called for special obstacles as woods and water, whereas gas led to the avoidance of woods, villages and low-lying places.

The German attack of March, 1918, then came to round off the lessons in defence which the war was teaching. And that attack really taught us the difference between "depth" and "dispersion." Ask any formation or unit, big or small, in the 5th Army why it retired, and the answer is because its flanks were turned. In many cases it was true, and the tactics of infiltration used by the Germans lent colour to that answer.

The lesson was that the machine-guns and the infantry must needs be grouped in defence posts. Each defence post is self-contained and can present a reinforceable front in any direction. A proper combination of inter-supporting defence posts forms a defended locality, which is an area of ground organized for defence by a definite unit or formation from a company to a brigade. A defended locality has its own counter-attack troops to restore its own situation if needs be.

And furthermore, defended localities are inter-supporting, and by being so, form the framework of the whole defensive system.

An area, on the other hand, held in "dispersion" has no such plan in its construction, but is merely an area containing lines and groups of armed men. Such an area provided a complicated system of successive lines of trenches which give an excuse for retirement and which use up many men.

The true system must be composed of inter-supporting self-contained defended localities, and must be, at the same time, simple; and to achieve such a form of modern defence is in itself no simple matter.

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THE CASE FOR LOW-PRESSURE HOT-WATER HEATING.

By CAPTAIN C. C. ADAMS, M.C., R.E.

IN the *R.E. Journal* of June, 1923, under the title of "Modern Forms of Central Heating," Brigadier-General W. Baker Brown, C.B., has given a description of a system of heating buildings which he believes should be of value to officers of the Corps. The article referred to does, however, leave an impression on the reader's mind that the pipeless system of central heating is the latest and best device, and that, while it is cheaper, both as regards first cost and running expenses, than other and more time-honoured methods, it is as economical and as effective as any of them. The present writer cannot claim any personal knowledge of pipeless heating, but he does feel that there is another side to the case. Heating by hot air without pipes is no new thing; it has certain inherent objections which have prevented its extensive use in the past, while, on the other hand heating small buildings by the circulation of hot water has advantages over other methods which should be carefully weighed before deciding to abandon such a well-tried and proved system.

There are many ways of keeping buildings warm in the winter months, and, naturally enough, advocates can be found for most, if not all of them. Under some circumstances, the open fire will give the best results, while, under other conditions, steam heating will be selected as the most economical system. An arrangement for heating a garage will not necessarily be effective for a church. Heating buildings is a science in which improvements are constantly being made in all branches; there are modern designs of open fires and stoves, and from time to time improvements in all forms of central heating are put on the market. It is really quite unfair to label a particular system "Modern Forms of Central Heating" and thus to imply that other methods are obsolescent. Such is by no means the case either in England or America and, although the pipeless system may have advantages, probably not even its most sanguine enthusiasts expect hot air to oust completely either water or steam as a vehicle for the transmission of heat from the furnace to the rooms.

The heating of buildings is an extensive branch of sanitary science, and it would be quite outside the scope of a short article to deal with all the methods in use. The writer, therefore, proposes to state the case more particularly for that branch of central heating

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which is generally accepted as most suitable for small buildings where expert supervision is not practicable, namely, low-pressure hot-water heating. In this system, the heat is conveyed to the rooms by the circulation of hot water through pipes and radiators, the pressure of the water being strictly limited owing to the pipes being open to the atmosphere at some part of the system. This method is in itself a large subject on which many books have been written, and it will be quite impossible to give any detailed description or calculations; the advantages and disadvantages will simply be compared with those of hot-air systems, and more particularly of the hot-air system known as pipeless heating, as described in the former article.

The utility of central heating would at first appear to be outside this discussion, as it is common ground on which both parties agree. It will not, however, be out of place to state the advantages usually claimed for it, as this will give us a basis on which to compare the two systems.

The main advantages of central heating are efficiency and economy. Efficiency is due to the use of one heat-producing unit instead of several, and to the fact that most of the heat from a central stove or furnace will be employed usefully, while in the case of open fires, some 50 per cent. or more of the heat produced usually escapes up the chimney without doing useful work. Economy of fuel is an important advantage, and there is further a considerable saving in labour—labour for carrying fuel, supervision and cleaning, the latter referring, not only to the cleaning of the grates themselves, but of the rooms, which soon become dirty with smoke and coal-dust from an open fire. A further advantage claimed for central heating is that not only living rooms, but all rooms, including halls and passages, can be given their measure of heat. In this way, draughts are avoided, and the whole building is raised to a comfortable temperature. Again, radiators can be so situated in rooms as to give the best circulation of warmed air, and in large rooms two or more radiators can be installed in different positions. With open fires, or stoves, such a distribution is not usually possible, owing to structural details and the positions of flues; consequently the temperature of a room heated in that way may not be evenly distributed. It is no uncommon thing to find one part of a room, heated by a grate, comfortably warm, or even too hot, while another part is quite cold. Or again, a man sitting in front of the fire may have his face and part of his body warmed, but at the same time feel decidedly cold down his back! Yet another advantage of central heating is that of rapid regulation. Radiators can be instantly turned on or off, and, with most systems, a partial turning of the valve handle will give a corresponding increase or decrease of heating power. The same applies to electric,

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gas or oil stoves, but not to a coal fire, which takes some time to "get going," and once it has been allowed to go out, must be re-laid before it can be re-lighted.

There are two disadvantages usually given for all forms of central heating, that it is not "cheerful," and that it does not promote ventilation. The latter point has been discussed by the author of the former article; the modern expert asserts that we get quite enough fresh air in our buildings without the use of open fires, and in any case, it is very doubtful whether the expense of installing them in all living rooms would be justified by the improved ventilation obtained. Here it might be pointed out that one argument given in favour of pipeless heating (p. 205) is that the same air is used over and over again, and so starts partially heated. The same argument applies to water in the case of hot-water heating. The question of "cheerfulness" is more important. An open hearth is certainly a cheerful thing in cold weather, and it is even doubtful whether the advocates of auto-suggestion would get the same satisfaction from sitting in front of a radiator as they would from an open fire. It has been stated that a house properly warmed by hot water has perpetual summer in it, and that the sight of a fire is not welcome or cheering on a summer day. This is an argument usually given by central-heating enthusiasts and may well appeal to some readers. The writer must, however, confess that it is an argument which does not overcome his English conservatism, and he will always vote for central heating with one or two open fires in addition in the principal living rooms.

Now let us see how far these advantages (and requirements) of a central heating system are met in the case of pipeless heating. Its efficiency compared with scattered heat-producing units is evident, but it is hard to believe that a current of heated air let loose in a house, and free to escape by the numerous cracks and crevices that exist even in the best regulated buildings, will be as efficient as a hot-water system confined by pipes and radiators.

There will undoubtedly be some economy of labour, but with the pipeless system we are liable to be confronted with the dust nuisance, for the current of hot air from the furnace may carry with it dust particles, even though there is no direct communication between the hot-air chamber and the fire-box.

As regards fuel consumption, we have been given some figures. With pipeless heating, we are told that 40 lbs. of coke a day will heat a ten-room house, but to what degree? And for how many hours of the day and night? Professor F. W. Dye is a recognized authority on central heating, and he gives useful figures as far as hot-water heating is concerned, and states* that for a 24-hour day,

* *Warming Buildings by Hot Water.* F. W. Dye. Published by E. & F. N. Spon, Ltd.

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under reasonably good conditions, the consumption of coke for installations of moderate size averages 1 cwt. a day for each 400 sq. ft. of radiation. Now assuming that in our ten-room house, six rooms require to be heated, and of these, three are living-rooms and three are bedrooms, all with an average capacity of 2,500 cub. ft., we find, from the figures given in Table 1 (*a*) on p. 61 of the *Water Supply Manual*, that the radiator heating surface required is 202½ sq. ft., and the coke consumption will, therefore, be about 57 lbs. a day. Professor Dye advocates a rather higher temperature than that required by the *Water Supply Manual* and, using his Tables, the consumption for the same house works out at 70 lbs. a day. From this it would appear that the pipeless system is the more economical as regards fuel expenditure, but the value of this comparison relies on the data being identical in the two cases, and we must know whether the 40 lbs. coke consumption given for pipeless heating is for heating throughout the 24 hours of the day, and what degree of temperature is attained in the rooms.

The question of the regulation and distribution of the heat is a very important one, and it is in this respect that the pipeless system appears at a distinct disadvantage. The only real regulation possible is at the " register " or grating through which the heated air passes as it leaves the apparatus. This would enable one to turn off, or to diminish the total volume of air entering the living rooms, but any regulation of the supply to individual rooms is impracticable. Obviously then, it will be almost impossible to have a warm room at the top of the house without considerably overheating the ground floor, particularly when a few windows are open. The makers assert that the warm air rises to the top of the house, rushes into every cranny and corner at all levels, and finally descends to be reheated. Surely there must be some fallacy in this, for the air will only ascend until it has cooled sufficiently to be heavier than the warm air rising, and will then begin to fall again. It is doubtful whether it will rise more than ten or twelve feet before this takes place. Further, if the kitchen premises are not entirely cut off from the rest of the house, they will receive their share of heat, and in some cases become intolerably hot ; in fact, they may even receive more than their share owing to the draught caused by the range. And then there may be rooms with open fires burning in them. If they are receiving their share of the heated air, it will surely be very hard to prevent overheating. In the case of low-pressure hot-water, a few turns of the valve-handle of the radiator would at once diminish the heat reaching any particular room. Also, in planning a hot-water system, the distribution of heat can be regulated to a nicety. Larger rooms can have larger radiators, and in small and unimportant rooms the heating surface can be cut down. Rooms which are near the furnace can have small radiators

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so that they will not rob more distant parts of the building. It is easy to make allowance for those rooms which have exposed walls, large window areas, etc. All this is impossible with pipeless heating, for with that system, all the heated air is discharged into the building at one spot, and no further regulation is possible. Referring to hot-water systems, the writer of the previous article states (p. 201) that "the circulation of the hot water is troublesome to regulate," but is this really the case? The reverse appears to be more exact. With steam circulation, it is true that a radiator must be completely "on" or completely "off," but with any of the low-pressure hot-water systems, partial turning of the radiator valve-handle is satisfactory, and regulation is possible at any radiator. Perhaps the paragraph quoted was intended to show that it was troublesome to walk round a building to turn these handles. If this is so, the remedy is not to turn the handles—even then, one is no worse off than with the pipeless system which has no handles to turn!

Another "disadvantage" of other systems mentioned (p. 201) is the stuffy feeling experienced in the buildings. Here we must disagree as far as low-pressure hot-water is concerned. The writer has lived in houses heated in this way on both sides of the Atlantic, and has never noticed any "stuffiness" on account of the heating. It certainly is found with the high-pressure system, and with steam-heating, and is probably due to the scorching of particles of dust and hair in the atmosphere, owing to the high temperature. It is particularly noticeable in steam-heated railway trains and many American hotels. It is also stated (p. 201) that, with hot-water circulation, the air feels uncomfortably dry. This is doubtful, and seems to be a matter of opinion, but the fault can always be remedied (when it does exist) by placing a small bowl of water on or near a radiator.

A "pipe" system is certainly comparatively expensive to install, owing to the more extensive apparatus and the cost of cutting through walls for the pipes. The pipes and radiators occupy space, and are said to be ugly. This, however, is a fault which has a remedy, and the illustrations of modern radiators, made by the National Radiator Co., Hull, show that the latest designs are not unpleasing to the eye. (*Figs.* 1 and 2). The wall radiator is made in various dimensions, with a depth of $2\frac{1}{4}$ in; it is mounted on special brackets, and then only protrudes slightly from the wall, and occupies no floor space.

The panel system is a modern method of heating, which is being used where an even temperature is required and radiators are undesirable. The arrangement of boilers and circulating mains is as for a radiator system and, when desired, panels and radiators can be used on the same mains. The heating surface takes the form of coils of jointless piping, fixed to the bare walls or ceilings, or in

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THE CASE FOR LOW-PRESSURE HOT-WATER HEATING.

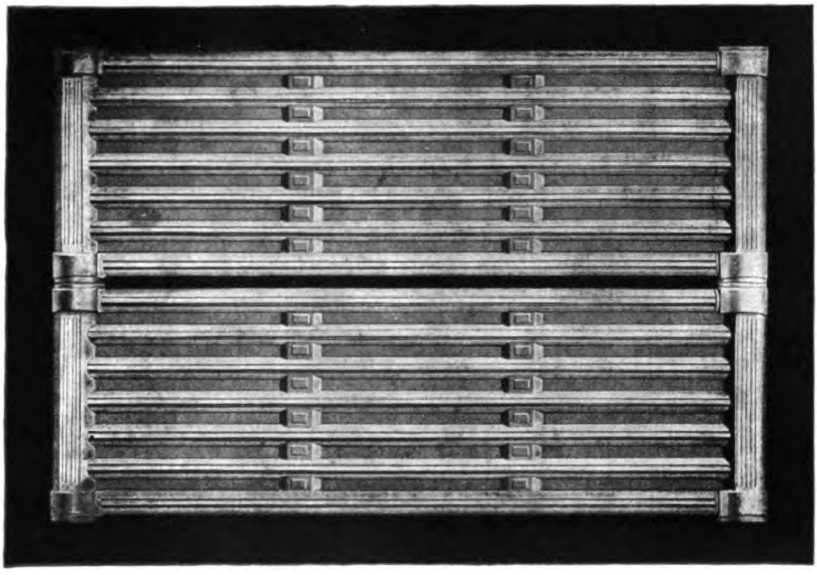

Fig. 1.

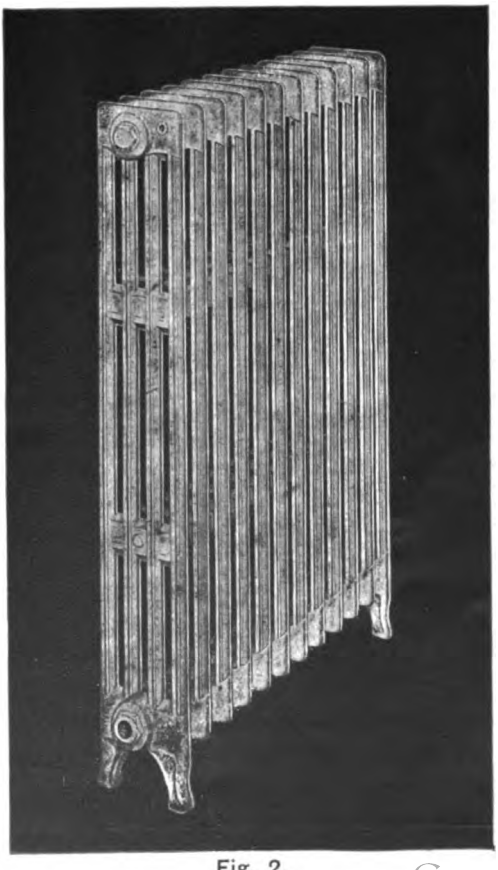

Fig. 2.

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Fig. 3.

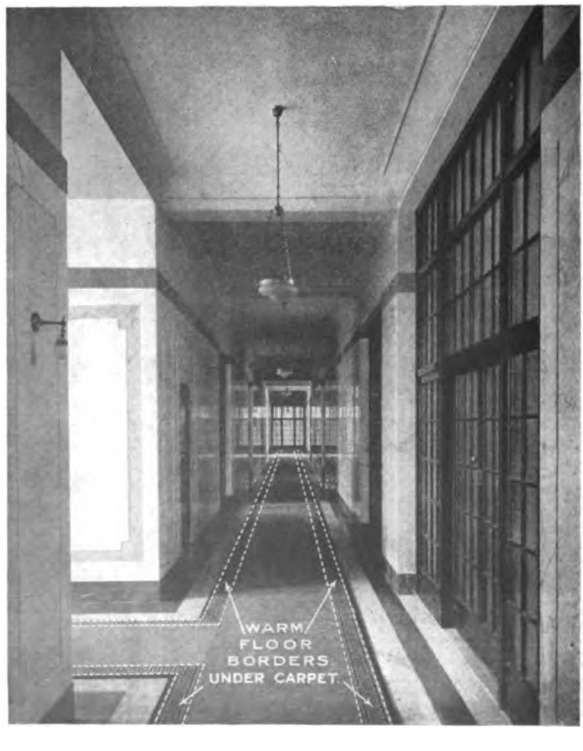

Fig. 4.

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the floors, and then covered over. The tubing is of special quality with welded joints, and is subjected to a high test pressure to eliminate any risk of breakage. When the coils are embedded in ceilings, or other places where there is no risk of perforation by nails, they may be made of soft metal jointless piping, which simplifies fixing, and reduces the weight to a minimum. Each panel or series of panels is regulated by a valve, exactly as in the case of a radiator system.

The panels in walls and ceilings are usually covered with a special plaster which is inexpensive, the finished surface being reinforced to prevent cracking. The arrangement of the coils does not permit of large movements due to expansion, and the covering material easily adjusts itself as the system becomes heated. The surface can be painted or distempered, or mouldings can be planted on it, if desired. Walls, or floors finished in materials such as marble, slate, tiles or mosaic are quite suitable for panel heating (*Figs.* 3 and 4).

The temperature of the water in the system is normally quite low (90°-130° F.) and this permits of increasing the heat considerably in very severe weather. It should be noted that the rooms are mainly heated by radiation from the walls, etc., comparatively little of the heat being distributed by convection currents in the air. This is not the case when radiators are used, for then, only a small proportion of the work is done by radiation, most of the distribution being due to the circulation of heated air. The promoters of the panel system claim that removal of the air by ventilation does not cause serious heat losses, and one can, therefore, heat a room with panels, even if the windows are kept open. A further advantage is the comparatively low temperature used, which will not cause dust particles, etc., to burn. The distribution of heat is uniform, and there is no risk of cold currents or draughts. It is claimed that the fuel consumption with this system is less than with any other form of heating.

The panel system is no doubt expensive to install in an existing building, but, with a new building, its cost will compare favourably with that of radiators. It would appear to be particularly suitable for hospitals, where an even temperature is essential, and radiators may collect dust.

The system is not a new one, but has been in use for some fifteen years with success. It is fully patented, and further information on the subject can be obtained from Messrs. Richard Crittall and Co., Ltd., 43, Bloomsbury Square, London, W.C.1. Panel heating has recently been installed in many large buildings, including the Stadium Building at Wembley Park and the Bush Building, Aldwych, but it appears to be quite suitable for dwelling houses as well as public buildings.

There are many piped installations which have given trouble in the past, but this is the fault of the architect, or builder, and not

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of the system. A properly designed plant will invariably work well. Central heating has not been used much in this country, owing to the mild winters and the conservative hankering after the open fire. Consequently, its principles are not always well understood by architects, and the latter hesitate to call in specialist heating engineers when only small plants are to be installed. This has been the cause of much trouble, but happily the essentials of designing installations are now better understood.

Heating by the circulation of hot air is no new thing. In America, it has been called hot-blast heating, and was probably the first way ever tried of heating buildings by a central furnace. It was found, however, that although the first cost was small, the stove was less durable than a boiler, and in case of damage to the stove (not an uncommon occurrence with this type of heating), or leaks caused by alternate expansion and contraction at the joints, sulphur dioxide and carbon monoxide from the fuel may get into the living rooms with disastrous results. Later, this method of heating was largely abandoned except in cheap houses where small first cost was of prime importance. In his book on heating, Mr. F. W. Raynes* expresses what the present writer believes to be the general feeling with regard to hot-air heating. "In America, hot-blast heating for public buildings, as generally carried out, is looked upon by many with disfavour. The high temperatures to which the air is usually raised bring about chemical changes by decomposing some of the contained dust. Thus the air loses its freshness, and becomes to a certain extent vitiated before it enters a room. It is also thought that the overheating process devitalizes air by robbing it of properties that cool fresh air contains." The same argument would apply to private buildings as well as public. The above paragraph has a general reference to hot-air heating, and was written before the pipeless system was introduced; the latter, however, appears to suffer from some, if not all, of the defects mentioned.

The suggestion was made that pipeless heating should interest the R.E. officer for financial reasons. D.O.'s want to save money, and there can be no doubt that this system gives a large saving in first cost, but let us remember that that is not necessarily economy. Cheapness means a lot to the D.O., but that cheapness must not be at the expense of efficiency. We have to consider the capital cost, the cost of upkeep and the running expenses, and against these must be weighed the interest on our money which we are getting in the shape of calories and comfort. For small buildings, low pressure hot-water heating pays good interest. It may be possible to say the same of pipeless heating, but we should be cautious in installing such a system before details of the running expenses over a number of years are made available.

* *Heating Systems.* F. W. Raynes. Published by Longmans & Co.

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THE INFLUENCE OF FAST-MOVING TANKS ON THE ENCOUNTER BATTLE.

By COLONEL J. F. C. FULLER, D.S.O.

PREFACE.

MY object in this paper is not to prove that the tactics and training made use of in our army are valueless or that existing weapons are useless, but that we are to-day living in a transitional period in which changes are beginning to take form, changes which, I believe, must radically modify our military conceptions. No man can say with certainty what is going to happen, but we may say with some assurance that only by attempting to probe the future shall we be able to discover the probable nature of the changes which confront us. In this paper I have outlined in brief a few ideas, they are nothing more than ideas, but they may assist as a working base for further speculation and research. Though we must adhere to the doctrine laid down, it should be remembered that one day all our Manuals will have to be revised and, consequently, if we have not thought out beforehand the new directions that war is taking, when we are called upon to assist in this revision we shall fail in our duty as soldiers.

PART I.

Argument.—In this paper I intend to deal with a speculative problem—the influence of a fast-moving tank on existing tactics and organization. It is a problem which has not been studied, except by a very few, and it is an immense problem. In order to bring it within the scope of an article, I intend to limit my speculations to an encounter battle between two Continental nations —Red and Blue, each possessing 1 Cavalry Division, 6 Infantry Divisions and 7 Battalions of tanks. In the Red Army the Tank Battalions are an integral part of each Division, in the Blue they are Army Troops. The tanks with which these two armies are equipped, I will suppose, are proof against armour-piercing bullets, possess a maximum speed of 20 miles p.h., and weigh about 10 tons.

I will now lay down two postulates :—

(i) The *arme blanche*, the bullet and wire are useless against tanks.

(ii) The tank is useless in thick woods, swamps and on the slopes of mountains.

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Accepting these, and that two-thirds of the theatre of war is open agricultural country, I will consider some of the possible problems which may arise under the headings of Approach, Contact, Deployment, Battle, Counter-attack and Pursuit.

Approach.—First, remember the nature of the tank organization of both sides; and secondly, imagine that war has been declared between the Red and Blue nations.

Red moves off in column of march. Its tanks, in most cases, have been distributed down to Brigades, for the Red C.-in-C. is a firm believer in close co-operation between tanks and infantry. Before the columns have gone very far there is a considerable amount of confusion. The tanks want to go eight miles p.h., the infantry will not go more than two. The tanks are turned off the roads into the fields, but their commanders find that delays occur and control is lost when they are confronted by streams, woods, thick fences, broken ground, etc., and so they look for spare roads on their flanks. They use these and poach on the communications of neighbouring Divisions. Much abuse follows and eventually they are withdrawn and placed behind their respective Divisions. A day or two later the Division cannot get their supplies up. The tanks are blamed—they block the roads. Besides, some Blue armoured cars have put the " wind up " one of the Advanced Guards and have shot a Brigade Commander whilst at breakfast, five miles behind the leading troops; so it is decided to put the tanks in front and the Red C.-in-C. issues orders that they are not to become engaged without infantry support.

Blue moves off in column of march, one central road is allotted to its seven Tank Battalions, the Divisions marching on parallel roads. When air reports inform the Blue Divisional Commanders that the Red forces appear to have their tanks in front, they become jumpy and urge the Blue C.-in-C. to give them tanks. He refuses and, quoting Ludendorff, tells them that the infantry " must rely on their nerves." If attacked, they " must move to a flank." He will support them when he sees fit. He is a man obsessed by the idea of " the manœuvre mass."

Contact.—The Red Cavalry Division is operating well in front of its infantry and is supported by a Battalion of tanks. These machines enter the Blue villages, terrorize would-be *franc-tireurs*, then along come the cavalry. When the ground is broken and difficult, the tanks stick to the roads and the cavalry canter out on their flanks and the advance proceeds rapidly.

One day the Blue cavalry are sighted. The Red Commander does not know whether they are working with tanks or not; he is, however, suspicious. He calls up his tank Commander and they consort a plan.

" You see those two woods to your right and left," says the Cavalry General, " Well, get into them. I will go on with the bulk of my force and engage the Blue Cavalry; there will be no charges,

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but instead, directly we are in contact, I will fall back across the fields between the woods. Once the enemy is well between them, you will attack him at top speed. If possible, I will wheel round the woods and attack all I can in flank. Do not attempt to co-operate with me, but seize your opportunity and, when you do, hit hard."

The Blue Cavalry advance with caution, they have heard that tanks are about and are much relieved when the Red are met without them. The Red troopers fall back and the Blue push on. The Blue attempt several charges, but are beaten back by machine-gun fire. The Red fall back on the two woods and then further back still. As the Blue approach, 60 tanks move out at top speed—some 18 miles p.h., and the best part of a Blue Brigade is wiped out. The rest retire in panic and do not draw rein until they reach their infantry advanced guard, which they demoralize with the wildest of rumours.

That night the Blue outposts are most unsteady. Every sentry sees tanks. Wild firing takes place and the outpost reserves stand to arms throughout the night.

Deployment.—The Red Cavalry have mysteriously vanished. Except for a few isolated sections of troopers nothing can be seen of them. The Blue are still completely demoralized and their horses useless. The advanced guards are in contact, both sides are deploying.

The Red C.-in-C., a man of methodical habits, is not going to rush the enemy. Under cover of his tanks he intends at first to deliver a frontal infantry attack with four divisions and turn the enemy's left with two. With these two divisions he would like to use more than two battalions of tanks. His Tank Battalions are, however, distributed; to withdraw one or more will create confusion and, further, will seriously affect the *moral* of the infantry who have learnt to rely on them. To withdraw individual companies is difficult. He must have some reserve force for his right flank, so he determines to withdraw one Division into reserve. He is very much annoyed at this change forced upon him through the difficulty of separating tanks from the other arms when close co-operation has become a recognized necessity.

The Blue Army is deploying rapidly, but the seven Tank Battalions on the central road are causing much confusion. The Blue C.-in-C. orders two of these battalions to join the Divisions on their right and left, and five to move to the right flank as an independent force. As the tank movements are to be kept secret, the machines must move out laterally well in rear of the infantry and under cover of darkness. As they cross the various roads, the artillery and transport columns are delayed and as night deepens confusion increases as the tail ends of columns try and catch up with their heads after the tanks have passed by.

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Battle.—The Red Army advances whilst the Blue is still deploying. The Blue troops are in a nervous state, particularly the infantry, and are seeking to take up anti-tank rather than attack positions. Their attitude is defensive. Several of their positions are in woods and on hilly ground. These clash with the positions the Blue gunners would like them to take up in order the better to support their attack. Co-operation is difficult to establish. The Blue infantry start digging in, though not a shot has as yet been fired.

The Red forces continue their advance. In many cases the infantry have thrown away much of their equipment in order to keep up with their tanks; the number of stragglers is increasing.

The two battalions of Blue tanks which have been allotted to the Blue Divisions have been pushed out well ahead of their infantry and for the most part are out of sight. The two tank forces meet and long-range fire opens. The Red guns are pushed up at a gallop. The Red tanks which have been ordered to keep close touch with their infantry, want to push on, but cannot; a good many get hit. Besides, the Red tanks are scattered on a wide front and are unable to concentrate against the Blue.

As the Blue tanks advance, the Red infantry opposite them break and stream to the rear. The Red gunners stand to their pieces and knock out several of the Blue tanks, but not many, as their speed makes them difficult targets.

The Red tanks move forward at the request of their infantry and soon lose touch. Then, as one Tank Battalion tops a rise, they see thousands of Blue infantry streaming away in the distance. All Red tanks are now moving rapidly forward, with every gun firing. The ground is littered with infantry equipment; Blue infantry are seen in all directions. Hundreds are caught up and shot down. The Blue gun positions are approached, some Red tanks are knocked out, but in a few minutes the tanks are on the guns, and the gunners, where they can, join the fugitives.

The Red tanks, pursuing the Blue infantry, have lost all formation.

The Red infantry, on the flanks of the penetration effected by the two battalions of Blue tanks, have fallen back and are seeking refuge in woods and villages and behind streams. With great difficulty the Red C.-in-C. collects some 60 or 70 machines and orders them to follow up the Blue machines which are manœuvring to avoid the Corps and Army Artillery. He is successful; a number of Blue tanks are shot down and the remainder, in attempting to withdraw, come up against a small river and, being unable to cross it, surrender.

In rear of the Red Army there is terrible confusion. Bad news has travelled swiftly and several of the supply columns are in panic.

Counter Attack.—The Blue C.-in-C. hears of the total rout of his infantry. Scarcely a company remains intact, for his reserves have joined in the *sauve qui peut.*

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Simultaneously, he hears that his communications have been attacked by hundreds of tanks—fear magnifies numbers. This attack has been carried out by the Red Cavalry Division and its battalion of tanks. The night before, they moved 25 miles to the left flank of the Blue Army and then inwards. The whole of the rear system of the Blue Army is in confusion.

The only force the Blue C.-in-C. has intact is five battalions of tanks. These are well out on his right flank, preparatory to attacking the left flank of the Red Army. He withdraws them to a river slightly in rear, a stream which runs at right angles to his original line of advance. He does so because by air he has learnt that great numbers of Red tanks are attempting to cross it. He wheels his five Battalions inwards and they sweep down the river.

The Red tanks are surprised and taken at a terrible disadvantage. Some try to cross the stream and are ditched, others try to withdraw and are shot down, a few get away.

The Red C.-in-C., hearing what has happened, recalls his Cavalry Division. The horses are dead-beat and some of the tanks are running short of petrol. That evening but a remnant of the force rejoins him. Simultaneously he learns that the greater part of his infantry are in flight. Rumour has it that they have been attacked by thousands of tanks and that Battalions are surrendering wholesale. As darkness falls, the roads are blocked by streams of fugitives. Panic is now in command; even familiar sounds, like the noise of a motor-cycle or the droning of an aeroplane, send mobs of men scattering across the fields in the dark. Except for the five battalions of tanks, under the Blue C.-in-C., there is not an organized body of troops on or near the battle-field.

Pursuit.—The Blue C.-in-C. orders a relentless pursuit. Then he counterorders it, for his supply services are in chaos and he cannot get up petrol for his machines. He cannot get rations for his men, he does not know where his men are, he does not know where his rations are; all he knows is that most of his lorries are overturned in the ditches and that their drivers have disappeared.

The condition of the Red Army is still worse. Hungry men start marauding, marauders soon become brigands. The peasants take to arms in self-defence. The Red Government goes down with a crash and is replaced by a patriotic but revolutionary assembly.

The Blue C.-in-C. withdraws his five Tank Battalions; re-establishes his railheads and assembles the equivalent of some two Divisions of infantry. He begins to advance on the Red capital. He enters it only to find that, as a political centre, it has vanished, and that the people have taken up arms. Everywhere he is met by an intangible foe. Rails are torn up, bridges destroyed and water poisoned. His tanks are invulnerable, but with 300 machines he cannot control an entire nation. Directly the tankmen get out of their machines they are shot at. His small force of infantry can

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just keep open one line of railway and, except for this line and the capital, the country is unconquered.

At the opening of hostilities six Divisions of infantry might have won through. Now he wants at least twelve, possibly eighteen for police work alone, as well as hundreds of tanks and armoured cars. His country cannot supply them and, whilst its Government is scratching its head, President Wilson descends in a parachute from a giant battle plane, patches up peace terms and Red and Blue lands have lived discontentedly ever since.

PART II.

Apology.—I must now apologize for the behaviour of the opposing Commanders-in-Chief. In place of criticizing their tactics, let us examine their difficulties. Both had been brought up in a certain school of thought. Both had been educated on Training Manuals which they were not allowed to contravene. In the Red Manual the Commander had learnt: "To seize and hold a position with infantry remains the only known way of destroying the enemy"; consequently, when tanks were given him, he looked upon them as handmaids to the infantry attack. In the Blue Manual, the Commander had learnt that shock is the decisive factor, so he, consequently, acted as he did.

Now, in my opinion, the initial mistake committed was that both these Commanders could not divorce themselves from particular points of view. A hundred years ago there were three arms—infantry, cavalry and gunners. To-day, we have a multiplicity of arms which are not infantry, cavalry or gunners. Why not, then, change our system of thinking and think in terms of close combat troops (the new infantry), protective troops (the new gunners), and pursuit troops (the new cavalry). Then examine each group, pull out the weeds and organize each so that each can co-operate within itself and later on, perhaps, all three groups can co-operate with each other. Do not let us bother about holding ground or conquering ground—let us organize movement; this is the crucial problem. I will now examine each phase of the above encounter battle.

Approach.—Throughout the approach we see one outstanding difficulty, the difficulty of co-ordinating movement. Though tanks are roadless vehicles, when they are not fighting, their normal position is on a road, just as the infantryman's is. Man is a roadless animal, but if he has to walk from Aldershot to London he goes by road and not across country. If he has to fight an enemy along the way, he will often get off the road, but whenever possible he will get back on it. In fact, he only gets off the road so that he may get along it the quicker. With tanks we must do just the same

The tank wants to go at eight miles p.h. and boils over if we try and make it go at two; the infantryman wants to go at two miles p.h.

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and boils over if we push him along at eight. As we cannot increase the marching-power of infantry we must produce a tank which can move at any pace without injury to itself. There is no difficulty in doing this. Then, if necessary, each company of infantry can have its own platoon of tanks and there will be no need to place tanks in front or behind formations, or on separate roads. If armoured cars come along, they will be ready to meet them. Such tanks can protect infantry as long as they move at from two to three miles p.h. Have we solved the problem? No!

Contact.—Cavalry can move for very short distances at twenty miles p.h., or for fairly long ones at eight. Can these tanks and cavalry co-operate closely? No! Why? Because tanks are protected against bullets and cavalry are not. The Red Cavalry Commander seems to have realized this, for he did not turn himself into a worm with the tank as the hook. If, in place of Blue Cavalry, he had met Blue tanks, I imagine he would have done very much the same thing. He would have used his cavalry as eyes, not as fists, and, if pursued, he would have scattered so as to reduce the target. He would, therefore, before he advanced, have settled on his " bounds " forward and have selected various rallying points if he were forced to scatter. In fact, he would be ready to dematerialize his command at any moment and materialize it again, anyhow in groups, an hour later and well in rear or to a flank. " Dematerialization " is the opposite of charging.

As long as tanks cannot move quicker than horses, cavalry will remain a useful arm.

A point worth noting in this contact engagement is that if, in war, we can strike a crushing blow first, even if we only crush a small force of the enemy, we not only gain a physical victory over the force we have crushed but a moral victory over every man behind this force. The lesson here is that cavalry and tanks, when working together, must act with the greatest audacity and cunning. To avoid jealousies they should belong to one mobile arm—the pursuit troops. Pursuit does not necessarily mean waiting until an infantry battle has been fought. If we are mobile soldiers let us get the infantryman out of our heads and pursue whenever we can. Our object is not so much to " fix " the enemy, but to endow him with extreme mobility in the opposite direction to which he wishes to go. Why? Because by so doing we shall turn him into a demoralizing projectile. We must always remember that the enemy has nerves.

Deployment.—Granted that the tank can, without detriment, move at the same pace as the infantry, deployment with tanks is no more difficult than deployment without them, especially if each Battalion has a Company of tanks of its own. In other words, we have dismissed the idea of infantry and replaced it by that of close-combat troops.

But have we really solved the problem of deployment? No!

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What is this problem? Rapidity of movement. The tanks can move at twenty miles p.h., that is, eight times the speed of infantry. Twelve miles of infantry take a whole day to deploy; twelve miles of tanks will take two hours, perhaps less. What if the enemy detach an independent Brigade of tanks to attack us whilst we are deploying? Should we detach a Brigade also to attack the enemy's Brigade and so cover our deployment, because we consider it essential that our close-combat troops must not exceed two miles p.h.? Here, once again, we catch ourselves thinking in terms of infantry.

What if we have not got an independent Tank Brigade up our sleeve? Are we going to let ourselves be run over? Would not we detach every tank we could from our close-combat forces to frustrate such an ignominious end? What would the infantry forces say? Would they console themselves with the idea that they were the decisive arm, that they can hold and conquer ground? What would their *moral* be like when their tanks, not as a united body but as a host of separate companies, disappeared over the skyline? What if their tanks were defeated? What if their tanks pursued the enemy thirty miles and defeated them? Are they going to double thirty miles to hold this ground? Or must their tanks abandon the idea of defeating the enemy and replace it by, "We must not go more than five miles or else our infantry will never get here by this evening."

By enabling a tank to go two miles p.h. we may have solved some minor march problem. Why not, in place, mount the infantry in cross-country buses which can move with the tanks and at the same pace? Instead of marching twelve miles a day they will then move one hundred, and deployment will be proportionately rapid and, if enemy's tanks are met with, the buses can fall back twenty miles in a couple of hours and, if our tanks beat the enemy thirty miles ahead, the buses can cover the fifty miles in some five hours and their occupants can hold whatever ground they like as long as their tanks remain close at hand. If their tanks move away, they can hold the ground against infantry. But is it likely that the enemy will attack them with infantry when he can make certain of victory by attacking them with tanks. If he does so, then the infantry will get into their buses and bolt. Their power does not rest in holding ground but in ability to abandon ground, and abandon it at a speed equal to that of the tanks.

Battle.—I will now turn to the battle. Why was it such an appalling chaos? The main reasons were because the tanks were bullet-proof and could move at twenty miles the hour, whilst the infantry were not bullet-proof and could not move at more than four, when in flight. Had they been provided with cross-country buses, most could have saved their lives, but what use would they have been as close-combat troops? None, except in areas in which tanks could not move.

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Either in buses or on foot, infantry offer no protection to the guns in rear against a tank attack. If overrun by tanks, their supporting gunners have to fire indiscriminately on friend and foe. If only the guns could be placed in front of the infantry, how much safer would the infantry be! This can only be done by putting the guns on tracks. For a moment I will examine this question of artillery.

In the recent war, tanks, which could move at four miles p.h., had to attack positions held by hundreds of guns. Many tanks were hit, but, in spite of all these hundreds of guns, every well-organized tank battle was a success—an overwhelming success. To-day, we have only seventy-two guns in a Division, and, in spite of the fact that some of them possess split trails, are they going to be as successful against tanks moving at 20 miles p.h. as the German non-split trail 77 s were against Mark IV. and Mark V. tanks?

Had the guns of the Red and Blue artillery been mounted on cross-country tractors or in tanks they could have protected the Red and Blue infantry. Their object would not, however, have been to effect this protection, but to destroy the enemy's tanks and tractor-mounted guns. The field-gun motorized is, in fact, no longer a protective arm but a close-combat weapon.

Counter-attack.—The Blue counter-attack succeeded not only because the Blue C.-in-C. had an organized force of tanks in hand, but because this force was homogeneous; it did not include arms which it had to protect but which could not protect it. The Blue C.-in-C. made full use of ground, not as cover but to restrict the mobility of his enemy's machines. He waited until they were hung up by a river and then attacked. This may seem a small point, but it is a most important one. We have been trained to appreciate ground from the point of view of cover and of fire effect. In the future we must also appreciate it from that of tank mobility. All our war maps will have to be changed. They will have to be coloured showing where tanks can go, where they cannot go, and where it is difficult for them to go. What we shall require in the next war are maps on the lines of sea-charts.

Pursuit.—Why did the Blue pursuit peter out? Because the Blue Army's supply system had gone west. To a mechanical army, its lines of communication are more vital even than those of a non-mechanical. This can be partially overcome by oil and gas producer plants, but as long as tanks are driven by petrol, communications must be safeguarded or else fleets of "tramp" aeroplanes must be created to convey fuel to them.

And now as to the last question. Why had President Wilson to parachute out of the heavens like a falling Lucifer? Because, though armies can be defeated by machines, nations cannot be, except at a stupendous cost. To keep a nation in order we want men. Men who move everywhere, who go into houses and who can disperse meetings without bloodshed. To control a nation we want "human

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touch"; to conquer a nation we must establish order. When a nation rises, God help us, and to prevent its rising we must organize success and not merely gain victories. To organize success we want men, and the quicker we can move these men about the less likely are the people to revolt.

PART III.

Conclusions.—In my Apology I stated that a hundred years ago there were three definite arms—infantry, cavalry and artillery. In the 14th century there were archers, pikemen and knights. Wellington did not think in terms of archers, pikemen and knights, and he was right. To-day, we have new arms and we also must cease thinking in terms of the old. We are not certain of these arms, let us try to group them in the three essential groups.

(i) *Close-Combat Troops.*—Tanks, motorized field and medium artillery and motorized infantry, the last for attacking regions unsuited to tank action and for outpost work.

(ii) *Protective Troops.*—Motorized heavy guns and infantry pioneers. The latter to be used mainly on the lines of communications to build and garrison anti-tank block-houses and to lay mine fields. The duty of these pioneers is to hold ground and they should be equipped to do so.

(iii) *Pursuit Troops.*—Cavalry, as long as they are useful; fast, lightly-armoured tanks and scout tanks, also aeroplanes.

Behind this army of conquest will advance an army of occupation and of administration. It will consist of men and it will hold the countries won by organizing tranquillity within their boundaries.

Now I will conclude this paper by saying that I entirely agree with the *F.S.R.* when it tells us that infantry is still the decisive arm. I agree, because if we went to war to-morrow we should not possess sufficient tanks to wage such a battle as I have described. As long as we have no tanks we must rely on infantry. If a great war broke out to-morrow, I believe, because of the enormous number of machine-guns which now exist—five hundred to a Division in place of twenty-four as in 1914, the war would go static at once. Behind a wired machine-gun wall great tank forces would be created. How would they be organized, this is the question? Would we think of them in terms of infantry, cavalry and artillery? Of course we would, unless we had troubled ourselves to think out their values in other terms.

This, then, is the gist of my paper.

We must be loyal to the present, because we live in the present. Do not, however, let this prevent us being loyal to the future. To be disloyal to the future is to imagine that the present cannot change. It *will* change, and in terms of our ignorance or forethought.

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THE TALUS SLOPE, GIBRALTAR.

By MAJOR H. E. COAD, A.M.INST.C.E., S.R.E.S.

THE Talus Slope on the Mediterranean side of the Rock of Gibraltar consists of an immense bank of sandy earth overlying ancient detritus from the compact limestone of which at this point the Rock is formed. The sand has been blown up over this debris in the course of ages by the almost constant Levanters, and lumps of rock weighing from 30 tons downwards, the more recent detritus from the sheer cliff behind, are interspersed in it.

The area of the Talus is about 16 acres, and the angle of slope is, roughly, 35° on the average, but, in places, the theoretical angle of repose is exceeded. After heavy rains, the unstable material is washed down and nuggets of rocks are exposed and lie in a state of potential danger. Owing to the shifting nature of the sandy surface, any form of vegetation which might have tended to consolidate the surface is very sparse.

The only road from Gibraltar to Catalan Bay village and to Sandy Bay beyond, runs at the foot of the slope, and the danger to passers-by from falling rocks has for long been a bugbear to the Division Officers of the Gibraltar North R.E. Division, who are in charge of this area. Whilst narrow escapes from falling fragments are on record, no injury to life or limb has yet resulted at this point.

Falls of debris have, however, occurred a few steps further south at Catalan Bay, the most serious of which took place in 1811, when 18 inhabitants were killed. In 1910 a large boulder crashed through a tent of an Artillery Camp in Catalan Bay, the occupants of which escaped just in time. Again, in 1917, during a heavy storm, a large mass of debris fell into the village during the night, happily without loss of life.

The constant danger, therefore, has always been a cause of anxiety to those using the road, and this anxiety has been accentuated by the presence of the danger notices which prohibit loitering on the road in the vicinity.

Some years ago a deep trench was cut around the slope about 60 ft. above the road. Judging by the number of small rocks in it, this trench has undoubtedly saved many falls on to the road.

There recently were some large rocks near the crest of the slope, at an elevation of about 450 ft. above sea level. These were in the foot of an almost perpendicular bank situated above a moraine of very loose sand leading to a small precipice about 40 ft. high. These rocks weighed about 20 tons each. Whilst partly supporting the bank of the slope above, they appeared to be in such an unstable

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state as to be in imminent danger of falling. It was proposed to remove them, for, owing to their shape and size and the height they were resting at, it was considered that, should they slip, the trench would not stop them from reaching the road. The soil in which they were partly embedded was of so friable a nature that cascades of dry sand streamed down the bank wherever it was disturbed. The opinion was expressed that it would be better to leave these rocks alone, rather than to touch them and so endanger the upper bank of sand and stones, but after several inspections, it was determined to remove them and to smooth off the overlying bank, which at that point was lying at a slope of about 60° with the horizontal.

Owing to fears of a sudden landslide it was considered impracticable to attack the rock from below. The superimposed debris was therefore carefully removed by native workmen, roped well back to more or less safe ground. After exposing the rocks as far as could be safely done, it was seen that no further excavation by hand could be carried out without a serious risk to the lives of the workmen, since the loose material from above was cascading around and about them and there was a strong possibility of the whole of the upper bank collapsing. They were accordingly withdrawn and four slabs of guncotton laid just behind the key rock and detonated electrically. The main result of this charge was to partly shatter the key rock, but it was seen that the charge had shaken the supporting rocks and made the bank more dangerous still. A further charge of equal size was detonated and this completely blasted the key stone out. It was then a simple operation to start the remaining rocks with a crowbar, and about 200 tons of sand, earth and rocks moved slowly down the moraine, the large rocks gradually gaining impetus until they bounded with a roar down the slope, across the road, to find their destination in the sea. The appearance of the moraine after the fall was somewhat peculiar, a stream of sandy earth about 10 yards wide, with small boulders turning over and over in it, flowed sluggishly down, the material issuing from the bank above like water. For a time it appeared probable that the whole of the upper bank would collapse, but, after about 20 minutes, the stream moderated and came finally to rest several hours after the explosion, a large portion of the bank having fallen out.

A few small outstanding rocks were then overturned by hand and the upper slope appeared to be far safer than before.

It is intended to deepen the trench referred to above in order to make certain that any smaller rocks which may fall in the course of time will be caught, and it is believed that the whole of the Talus Slope will then be in a safer state than it has been within memory of man.

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AN EMERGENCY METHOD OF FIRE CONTROL FOR ANTI-AIRCRAFT ARTILLERY.

(*From the United States Army "Coast Artillery Journal."*)

By LIEUT.-COLONEL D. M. F. HOYSTED, D.S.O., R.E.

A CAREFULLY thought-out suggestion for control of anti-aircraft guns in case of sudden damage to all the height and deflection finding instruments, is set forth in the *Coast Artillery Journal* of the American Army for January, 1923.

It is the collaborated work of two captains of the Coast Artillery Corps. The method consists of the use of a diagram previously worked out for each class of gun, projectile and fuse in general anti-aircraft use. The diagrams vary also with the pre-assumed speed of the hostile plane. In general terms the suggestion is that the gun commander should have a series of the diagrams always at hand, so that in case of such emergency he could at once make use of the one which should most nearly suit the needs of the moment.

The diagram consists of five concentric circles plotted to scale and representing angular heights of 75, 60, 45, 30 and 15 degrees respectively, round a centre point which is designated "Position of Plane." From the same centre, and cutting all the circles, are plotted radii at 15° interval, labelled as under :—

(For this description comparison has been assumed to a compass card with the 0° line at 12 o'clock of the circle.)

Radii on	0° and 180°	(compass)	lines	labelled	Going 0° and Coming 0°
,,	90° and 270°	,,	,,	,,	Passing +90° and Passing −90°
,,	15° to 75°	,,	,,	,,	Going +15° to Going +75°
,,	105° to 165°	,,	,,	,,	Coming +75° to Coming +15°
,,	195° to 255°	,,	,,	,,	Coming −15° to Coming −75°
,,	285° to 345°	,,	,,	,,	Going −75° to Going −15°

It will now be seen that each radius cuts five circles and each circle cuts 24 radii. At each cutting point is a small rectangle, called by the author a "box." And in each box are shown certain readings for altitude, fuse range, vertical deflection and lateral deflection—five readings for each.

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The height readings in each case are the assumed heights of one, two, three, four and five thousand yards.

The corresponding readings for fuse and deflections have been worked out for those five heights on the assumption that the engine speed of the hostile plane is, say, 110 miles per hour.

Each box (except seven) therefore contains five sets of readings dependent solely upon the assumed altitude of the target.

The seven boxes on 75° angular height circle and on radii 125° to 225° inclusive contain the instruction "Hold fire until target is going."

The readings have been calculated on "A dead time of maneuvre of eight seconds . . . in determining the various fuse ranges (*sic*)."

The "gun pointer" lays on the target and announces the angular height.

"The battery commander makes an estimate of the angle of approach of the target and its altitude."

The battery commander consults the "box" at the junction of his estimated angle of approach radius and angular height circle, and takes therefrom the fuse range and deflection under the figure for the nearest estimated altitude of target.

Thence he makes his bracket and necessary corrections.

A series of Addenda to the diagrams show how to calculate quickly any variations of speed below or above the actual engine speeds for which the diagrams are designed. These corrections apply to variation of engine speed of 15 miles per hour on either side of the normal speed shown for the diagram. The diagram for a normal speed of 110 miles per hour would therefore be used for engine speeds varying from 95 to 125 miles per hour.

The use of such diagrams might be of assistance to a battery commander who had absolutely no instruments of precision to assist him.

The American collaborators also point to the use, in future, of heavy machine-guns and automatic guns of small calibre for the attack of aircraft.

The projectile of the latter to be a small explosive percussion shell, with a fuse sensitive enough to burst on contact with any part of the aeroplane.

This seems to take us back to an improved type of pom-pom such as we used for attacking hostile aeroplanes in France in 1914.

When watching such attacks, at the beginning of the war, the author could not help wondering where the hundreds of small 1-in. shells *did* eventually burst, as they never seemed to hit the target.

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Anti-Aircraft Defence in France.

The rôle of the Anti-Aircraft Defence Service appears to be as follows :—

A. *At all times, both by day and night.*

1. To keep Headquarters and the Air Service informed concerning all activities of the hostile Air Service and prevent surprise from the air.
2. In case of probable aerial attack to warn all persons concerned in sufficient time for the necessary counter measures.
3. To provide both military and civil authorities with information concerning the construction of bomb-proofs against aerial attack.

B. *By day.*

1. To co-operate with the Air Service to prevent, by direct attack, hostile aircraft from crossing the lines or frontier, and, if they succeed in crossing, to hinder them from accomplishing their mission.
2. To hinder hostile aerial observation by means of camouflage.

C. *By night.*

To ensure protection against aerial attack on important points such as headquarters, parks, depôts, stations, etc., by following means :—

1. Attack of hostile aircraft with artillery at certain points in their course and close to the important points to be defended.
2. Creation, by means of searchlights or other method, of series of illuminated spaces within which the defending planes may operate.
3. Obstacles in the probable route of hostile aircraft.
4. Leading hostile aircraft astray by camouflage of reference points and objectives.
5. Rendering targets invisible or modifying their appearance by camouflage.

To obtain the above results a broad " belt of detection " is to be maintained near each frontier in the hope of rendering it impossible for hostile craft to enter French territory without being seen or heard.

These belts of detection consist of observation posts which are to be situated not more than 15 km. apart, and which will be united in groups to " Information Centres of Anti-Aircraft Defence," which will, in turn, be grouped and united to " Centres of Anti-Aircraft Defence."

The telephone lines connecting these posts and centres are on no account to be put to any other use.

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There are three types of 75-mm. gun mounting used in the Anti-Aircraft Artillery: the automobile mounting, the towed mounting and the fixed platform mounting, of which the relative mobility is obvious.

There are two forms of listening apparatus in use, the Bailland and the Perrin, the former of which is heavy and can only be used in fixed positions.

They are still in more or less the trial stage.

The searchlights in use are of 90, 120 and 150 cm. and are mounted on wheeled carriages hauled by a motor tractor which also forms the generator.

They are used in groups of eight lights some 3 km. apart, three such groups forming a Searchlight Company. It is laid down that the lights should be constantly moved to new sites so as not to form a guide for the hostile craft. Upon instructions received during the morning, a Searchlight Company should be able, by the same evening, to organize its portion of a light defence zone within a distance from its station of 50 km.

When machine-guns are used against low-flying aeroplanes, the French method is to use them in groups of at least eight guns echeloned with reference to each other: fire is controlled by bursts of 15 or 20 shots from each gun.

In the French Army the Camouflage Service has formed part of the Anti-Aircraft Defence Service since 1918, as it is principally used as a means of protection from aerial observation.

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MILITARY SURVEY.

By MAJOR M. N. MACLEOD, D.S.O., M.C., R.E.

SURVEY has long been regarded as a soldierly accomplishment and the construction of maps has been for many years an essential preliminary to the orderly and methodical conduct of a campaign. It is to be expected, therefore, that evolutions of tactics and armaments will entail corresponding alterations in the requirements of armies in these respects.

It is, perhaps, unfortunate that the evolution of maps and surveys, which have become rather technical subjects, has resulted in the ordinary fighting soldier regarding them, in great measure, as things which must necessarily be left to the "expert" and with which he has no direct concern except in so far as he has to make use of the results of this expert's labours.

Nevertheless, military topography has for many years formed part of the military education of every officer; and in the light of recent experience it may be predicted that it will continue to do so for many years to come. The great war has, in fact, accentuated the importance of topography at the same time that it has introduced us to new conditions which radically affect the principles of its application to military operations and the training of officers and men in it.

In this article it is proposed to examine the application of survey to tactics in the light of recent war experience, to point out the effect of modern developments of armament, and to suggest the lines on which training should be carried out.

Up to the commencement of the great war the accepted doctrine took little or no account of the possibilities of survey work as a tactical auxiliary and envisaged a map almost solely as a means of finding the way about a strange country. Tactical details of any operation were invariably worked out on the ground itself after the arrival of the troops or their commanders on it. The topographical training of officers was directed to the understanding of any maps which might be in their possession (*i.e.*, map-reading) and to the construction of rapid sketch maps to enable them to deal with situations in which no map at all was to be had.

Modern developments have affected this doctrine in two ways. In the first place, the power of modern weapons is so great that time and opportunity for examination of the ground held by the enemy, after the fighting troops approach it, can no longer be counted

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upon. The great extent of modern battlefields rules out the possibility of personal reconnaissance of the ground in detail by the higher commanders.

Whenever it is possible to do so it is better to study the topography beforehand with the aid of an accurate and detailed map and to work out the details of an operation to the fullest possible extent before it begins.

In the second place the introduction and development of aerial photography enables us in any given time to prepare sketch maps far surpassing in extent, accuracy, and detail, anything that could possibly be done by partially trained individuals on foot.

In the use of the map on the actual battlefield also, important changes have taken place which affect profoundly the type of map which it is desirable to provide. These changes are mainly the result of the increasing " specialization " of armaments ; progressive gains in power being offset by a progressive difficulty in ensuring effective use, until the efficient co-operation of the various arms in battle has become the outstanding tactical problem of the day.

As long as men continue to fight with projectiles the aim of tactical methods will be to force the enemy to expose himself to view and then to destroy him from a distance without exposing oneself. This leads naturally to the sub-division of forces into two parts, one of which attempts to close with the enemy to discover where he is, and the other of which attempts to destroy him by indirect fire at continually increasing ranges as soon as his position has been found.

In practice, what all this amounts to is that, if the arms employing long-range fire, *i.e.*, artillery and machine-guns, are properly to protect the infantry while they are exposed in closing with the enemy, it is essential that as soon as the enemy is discovered, the artillery, etc., should be informed exactly where he is ; and that when they receive this information they should be able to attack and destroy him before he can either injure the exposed infantry or escape to another position.

Hitherto the latter aspect (the destruction of the enemy) has perhaps been studied more closely than the former (the discovery of his position) and we have evolved artillery methods which do enable guns to attack with success targets which they cannot see but whose positions are known. The problem of locating targets has not yet, however, been seriously taken in hand, and we have been content to assume that the position of an artillery target can be located by direct observation (*i.e.*, without any special apparatus, etc.) in one or other of the following ways :—

1. By the battery itself from its O.P.
2. By observation from the air.
3. By the infantry or other front-line troops.

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If, however, any of these methods is examined, it is seen that each is subject to many limitations.

The first presupposes that the battery can, and has time to, establish observation over the target, when the observer, having first located the O.P., may derive the position of the target by estimation (or guesswork) from it.

The second is only possible when the target happens to be near some topographical features and the airman is in possession of a suitable map showing these features in such a way that he can identify them correctly.

The third, like the others, depends either on the map or on a preliminary determination of the position of the observer.

This hypothetical observer, whether he be infantryman or gunner, has, however, at present no means of determining his position, or that of the target, except by "map reading"—at best, a rough-and-ready method, which depends on the following tacit assumptions :—

(*a*) That a suitable map is available.
(*b*) That there exist on the ground topographical features in the immediate vicinity of the observer or the target which he can identify.
(*c*) That the distances and directions of these features from the observer or from the target can be accurately estimated or guessed.

None of these assumptions is justified. "Map reading," in short, cannot be relied on for this purpose. It has, in fact, received innumerable trials and has repeatedly failed, and this, even when good maps and numerous topographical features were at hand.

These failures are usually ascribed to the inability of some individuals to read a map, but this is not really the true cause, which lies in the inherent shortcomings of the method.

When bad maps only are to be had, or, as in desert fighting, when there are no topographical features, it is quite obviously useless, and it can hardly be contested that a better and more reliable method is urgently needed. In such cases the problem of the observer is, in essentials, identical with that of the sailor steering his ship into harbour, or of the detail surveyor setting out to make a map. Each of these solves the problem in virtually the same way, deriving his position, when necessary, from previously fixed points, not necessarily in his immediate vicinity, by instrumental observation.

This determination from fixed points—resection, in fact—may be done in various ways. The surveyor finds a plane-table convenient, the sailor uses a sextant and a station pointer. In neither case are the particular instruments employed well adapted for use by an infantryman, but there is no reason why they should not be

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simplified. The principle is simple enough, depending, as it does, on the measurement of two angles only, and in the prismatic compass the officer already carries an instrument for measuring them; the result may be worked out either by the observer himself or by someone else, say at Battalion Headquarters, to whom he can transmit his observations.

The working out of the result with an instrument such as a "station-pointer" of simple design can be done quite mechanically in a few minutes and requires no technical knowledge of any kind. The only points which require consideration are the accuracy required in the determination and the form in which the result should be obtained.

To decide these points it is necessary to turn to the other side of the picture and consider the action of the gunner who has to hit the target once it has been located.

If the target can be seen from the Battery O.P. or by any intelligent person in communication with the battery, fire can be corrected by observation and great accuracy in the location is not essential. Speaking generally it may be said that the trend of most of the tactical methods we are now trying to work out, is based on the idea of enabling anyone in a position to observe the results of fire to report the results of his observation to the battery firing, in such a way that the battery can make the corrections required to get on to the target; thereby hoping to cut out the delay caused by the battery itself having to establish an O.P.

From every point of view it is desirable that methods of correcting artillery, and long-range indirect fire generally, by observation (whoever the observer may be) should be worked up, but the difficulties to be overcome are formidable, particularly when the number of batteries in action is large. In our endeavours to overcome these difficulties we must take care not to lose sight of the advantages to be gained from the ability to place the fire right on to the target from the outset without any observation at all. If this can be done the enemy has no time to get under cover or escape while ranging is going on, and the chances of inflicting material and moral damage on him are very greatly increased. It might be added also that correction of fire by observation is much simplified if the opening rounds fall close to the target.

The problem of effectively engaging a target without observation depends on, firstly, a knowledge of the performance of the gun under varying conditions of weather; secondly, on the ability to work out the direction and range of the target before fire is opened; and thirdly, on the ability to lay the gun in the required direction thus worked out; the accuracy required in the last two being commensurate with the accuracy obtainable in respect to the first. The Artillery are addressing themselves to this problem, and are

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within measurable distance of its solution. This is the chief *raison d'être* of what is now called " Artillery Survey."

It is unnecessary here to go into details of the procedure adopted ; the basis of it is resection from trig-points, and it may be said that if these are available in sufficient numbers the gunner can already undertake to engage, without observation, any target within range with reasonable prospects of success, provided he knows its correct position within certain limits of accuracy.

The limits of accuracy required are conditioned practically by the width of the " 50% zone " of the particular gun used and may be taken roughly as something between 10 and 20 yards ; a degree of accuracy, in fact, considerably higher than anything ordinarily attainable by map-reading without the aid of instruments, particularly on small-scale maps.

In order to simplify and speed up the procedure, which necessarily involves a certain amount of observation and calculation, the gunner prefers to work on a system of rectangular co-ordinates, and it is on the same system that the position of the target should be reported to him. " Clock-codes " and similar methods of indicating targets, which are now officially advocated, are really only makeshifts which do not allow the gunner to get full value from his piece. If the gunner can and does work by rectangular co-ordinates there is no reason whatever why other arms should not do so also, basing their determinations of their own positions on observation of fixed points, either trig-points (if suitably " beaconed " and visible) plotted on a grid, or on map-points taken from a large scale-gridded map. These determinations are, of course, only a step towards the final object, which is the position of the enemy, and although exact knowledge of the position of our own forward troops is invaluable to gunners and everyone else in rear of them, it is not a solution of the whole problem.

Provided, however, that the advanced troops can determine their own positions, they possess, in compasses and range-finders, instruments with which they can locate the enemy with very fair accuracy up to distances of, say, 600 or even 1,000 yards. At greater distances than this it is probable that special arrangements of some kind would be necessary. The problem is essentially a survey problem susceptible of several possible solutions, all of which may require special training, or in extreme cases, special troops.

There is always a natural reluctance to employ any man who would otherwise be handling a rifle or other lethal weapon on " auxiliary " work of this kind, and before suggesting that anything of the sort should be done it is advisable to consider the problem again and weigh up precisely what advantages are to be gained by its solution.

Suppose that it is admitted that the infantry can in no circum-

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stances locate a target with the accuracy necessary to enable the gunner to engage it without observation ; what does this imply ?

It implies that effective artillery support in a moving battle cannot be given until the artillery can establish observation over the target. It implies guns accompanying the infantry ; the use of artillery in a manner which exposes it unduly to the enemy and which makes the supply of its ammunition extraordinarily difficult.

If, however, targets can be precisely located by any means, it means that any gun within range can engage them, without waiting to establish observation ; artillery support need not be confined to such guns as can accompany or maintain direct communication with the infantry and can be given without the same restrictions as to expenditure of ammunition or exposure of the gun crews.

The two alternatives are not " shall we withdraw so many riflemen and arm them with survey instruments which hurt no one ? " but ' Shall we provide a few surveyors to locate targets and hope thereby to save many gunners, and also many infantrymen who would be protected by the gunners' fire ? "

The number of men required for this purpose is not large, and it can hardly be doubted that, if they can do what is expected of them, they will be more than " worth their place."

If it is accepted that some special arrangements for locating targets are necessary, the true alternatives which require consideration are, whether an attempt should be made to train the fighting troops to do it themselves, providing them, if necessary, with special equipment for the purpose, or whether a proportion of special troops, trained and equipped for the purpose, should accompany the fighting troops.

If it proves to be practicable the first alternative would always be preferable, both because administration and command of small detachments accompanying other units is troublesome, and because a special detachment would probably not be occupied for more than a fraction of the time covered by an operation and might not be on the spot when wanted.

Provided that the fighting troops are backed by a survey organization strong enough to provide adequate and suitable data, there does not seem to be any insuperable difficulty in training troops—officers and senior N.C.O.'s at any rate—in methods of making use of it.

If this argument be accepted it follows that the topographical training of officers and men should not be directed, as heretofore, to the production of indifferent sketch maps, which can be made much more efficiently by aerial photography, but should form part of a considered survey policy bearing a definite relation to the weapons in use and the method of their employment.

The aim of this policy should be to enable troops of all arms to locate their own positions and those of the enemy on the field of

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battle, up to a limit of accuracy which may be fixed for the present provisionally at about 20 yards.

The methods by which they have to do this should be specifically adapted for use on the battlefield. This rules out all methods involving walking about, such as the " pacing " of distances, which have hitherto been the foundation of the topographical training of officers and men, and compels reliance on methods of resection depending on the observation of previously fixed points with suitable instruments.

The positions of these points must be defined in a simple manner well adapted for communication to others; this points to the use by all arms of a single system of rectangular co-ordinates extending over the whole field of operations.

These points must be fixed by technical services, the R.E. Field Survey Units, whose numbers and equipment should be such as to ensure that they will be available in good time for any operation.

If sufficient natural features suitable for such points do not already exist, the Field Survey Units must be prepared to erect artificial beacons and to arrange for their illumination so that they can be seen by night as well as day.

(In war, the hours of darkness are often the only times when survey work in close proximity to the enemy is possible; up to the present time we have neither practised nor made any provision for such night work.)

In addition to these fixed points the Survey Services should aim at the provision, at the earliest possible moment, of an accurate large-scale gridded map. This map should be called a " Tactical " map and should not be regarded as an alternative to the trig-points, but as a supplement to them. It is simply a convenient way of showing the positions of terrestrial features on the grid, which is the basis of the whole system.

Such a system of grid and fixed points is already being used by the Artillery and will have to be provided for them; it is only a short step forward to ask the infantry and other arms to make use of it also.

In addition to determinations of position it is necessary to consider the question of fixing heights. In hilly country a knowledge of the relative heights of gun and target is often almost as important as knowledge of their positions; the determination of height is, unfortunately, considerably more difficult, and can hardly be done with the instruments at present carried by an officer. It would seem that reliance must be placed for the present on a contoured map, though something could undoubtedly be done with aneroids and small portable clinometers if the troops who have to use them could be persuaded that the results of their use were of value, and no maps were available.

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The problems the R.E. Survey Services have to solve are, firstly, how to carry forward a triangulation or traverse system at a speed equal to the rate of advance of an army, or how to lay down such a system at any stage of its advance in time for it to be of use in any considerable action ; and secondly, how to prepare an accurate large-scale map, showing, more particularly, contours, for some distance ahead of the front line troops.

The difficulties to be overcome are serious, but he is a pessimist who would say that the resources of the Corps in brains and energy, if they are applied to the task, cannot overcome them. It is, in fact, here contended that a system of fixing positions direct from trigonometrical points established by a special organization, is perfectly practicable, provided it is properly foreseen and organized, and that it is in general much more accurate and "fool-proof" than one which depends on the nature of the country (*i.e.*, on the existence of numerous well-marked features easy to identify) and on the possession of accurate large-scale maps of it.

In certain types of country, such as England and similar highly developed regions, "map-reading" may occasionally be simpler than resection from fixed points, because of the difficulty in establishing such points and the numbers of them which would be necessary. The difficulty of establishing points, in such places may be admitted, but it is precisely in such regions that the existence of good maps is most probable and the dependence, as regards accuracy, on observation of points would be least.

Even so, the fact remains that resection with instruments from map-points, such as cross-roads, hedge-corners and the like, is the best and quickest way of accurately fixing the position of any point which does not happen to coincide with some feature already shown on the map, and that rectangular co-ordinates and a grid system are the best means of defining this position when it has been determined.

The fact that it would be difficult to establish sufficient points or that they would be unnecessary in such country is a poor argument against a system which can be applied most easily in those regions where our present methods have been proved as most likely to fail, and to which, at the present time, our attentions are principally directed.

Provided a satisfactory solution of the technical problems can be found, as assuredly it can be, surveys and maps can be regarded as definite tactical accessories and the instruction of troops in the correct method of making use of them should be comparatively easy, much easier, in fact, than our present systems of so-called "Map-reading" and "Military Topography."

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LIGHT FLOATING BRIDGES IN MESOPOTAMIA.

A Lecture delivered at the S.M.E., Chatham, on 11th October, 1923.

By MAJOR F. V. B. WITTS, C.B.E., D.S.O., M.C., R.E.

Introduction.—In my lecture to-night, I am going to try to give you some idea of what was involved in bridging large rivers like the Tigris and Euphrates. The whole campaign in Mesopotamia was inseparably bound up with them, whether as lines of communication, as sources of water supply, or as obstacles. They were consequently always with us and equally always had to be bridged. And yet in the *Bridging* volume of the *Work of R.E. in the European War*, 1914–19, there is no reference whatever to the campaign in that country.

My lecture is based chiefly on my personal experiences, and, before going further, I wish to apologize for its inevitably personal character.

I arrived at Basra from France on 1st January, 1916, and was left with my half-company of No. 4 Company Bengal Sappers and Miners to assist in building landing stages.

In the middle of March I was given the command of a newly raised Bridging Train, which was arriving from India. Its basic strength was 80 Indian sappers, afterwards increased to 100, and it arrived without any sort of equipment whatever, so I had a hectic week collecting tools and stores. Pontoons were arriving from India, of the Indian pattern made of sheet iron; in those days stores, etc., were still unloaded from the transports in midstream, and the embarkation authorities thought they had at last got something easy to handle, which needed only to be lowered into the river and floated ashore. However, they soon discovered their mistake—the pontoons were of such an inferior workmanship that they could not stand the knocking about of transit, and sank as soon as they reached the water. It was a bright beginning.

Orah.—We got up to the front at Orah at the end of March, 1916, when preparations were being completed for the final attempt to relieve Kut, and immediately took over the boat bridge there. This had been constructed by the Madras Sappers and Miners and was still being maintained by one of their field companies.

This bridge was some 400 yards long, and consisted of country boats known as *bellums* and *mahelas*. Those in use varied from

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4 to 7 ft. beam, 25 to 40 ft. in length and 5 to 7 tons carrying capacity. The roadway, consisting of extemporized pontoon equipment superstructure, was carried on small trestles built up on the keel and supported on the gunwales. Like all the other bridges I refer to to-night, unless specially excepted, it was a light bridge, *i.e.*, for infantry in fours and vehicles of 2-ton axle-loads.

The river was then in full flood, running at 6 or 7 knots in the fastest places, and very stormy weather had been experienced. As a result, the bridge was, more often than not, quite impassable. It had consequently been decided to introduce larger boats in the most exposed portions. These were of the same design but much bigger, 13 to 17 ft. beam, 50 to 60 ft. in length and 40 to 70 tons carrying capacity. In their case the roadway had to rest on the gunwales, which required no special strengthening, but to keep them on an even keel, as a load passed over, their masts were utilized. These were spars of 50 to 60 ft. in length with a 12-in. base diameter, and they were firmly lashed right across the gunwales of every two neighbouring *bellums* on both sides of the roadway.

The bridge was anchored by every description of cable, from 4-in. manila and 3-in. steel downwards. The anchors used were the grapnel anchors belonging to the *bellums* themselves, varying between one hundred and two hundred pounds in weight.

The work of changing the boats had hardly been finished when a gale of wind blew up from the south-east against the current and I had my first experience of what a storm on the Tigris meant. Waves were anything up to 6 ft. in height and the bridge was frequently clean swept by them. All my sappers were continually on duty keeping it from breaking up or sinking. It was impossible to walk on it without serious risk of being thrown or blown into the river, and crawling on all fours was the only safe method of progression. Road-bearers were wrenched off their saddlebeams, and chesses were thrown into the river. Some of the sappers even suffered from sea-sickness. It soon became obvious that the rigidity necessary to save the superstructure from being broken up, and achieved by diagonal bracing between boats, would only lead to the smaller boats being swamped. The superstructure was therefore dismantled and the boats left to ride out the storm. Later on, life-belts were issued at the rate of one per sapper for use on similar occasions and, at any rate, greatly reduced the anxiety of mind of the Bridging Train commander.

Sandy Ridge Bridge.—To accompany the relief force, in its attempt to reach Kut, material for a second bridge had been collected, consisting of Indian pattern pontoons and light *bellums*, to be towed up river by tugs. Our disappointment was great in being left behind to look after the Orah bridge, but my men were all recruits and entirely inexperienced in bridging, and the mobile bridge was

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therefore entrusted to two field companies of the Madras Sappers and Miners. It was erected at Sandy Ridge, where it remained until after Kut had fallen: it was put across at the top of the flood in another appalling storm, and the work took 24 hours; it was only kept afloat by a liberal use of tarpaulins, of which, fortunately, a large supply had been arranged for.

Orah Bridge.—Although deprived for the moment of the interest and excitement of accompanying the relief force, our life on the bridge at Orah was full of incidents, of which I propose to relate a few.

On one occasion a motor-launch came across the river too close above the bridge and was carried by the current down on to one of the bigger *bellums*. The launch sank immediately and was never seen again. The occupants managed to catch hold of various ropes and lashings and were soon pulled out by my sappers, who were very astonished to recognize in the dripping party the Commander-in-Chief of the Expeditionary Force, his C.G.S. and two or three other highly-placed G.H.Q. officers. They had a very narrow escape.

On another occasion a small steam-tug fouled the bridge in the dark and remained broadside on, resting on the bows of the boats: the crew, perhaps wisely, leapt on to the bridge, and got clear. However, nothing happened for the moment, and something had to be done to try to rescue the launch and the bridge, both of which were in imminent danger. Fortunately the Mejhidieh—the largest river-boat in the country—was anchored just below, and the commander agreed to proceed above the bridge, anchor, let down a boat and cable to the tug and try and haul it off. He succeeded on his second attempt. This was Lieut.-Commander Cowley, who, a few days later, lost his life in a gallant attempt to run a shipload of provisions through to Kut and was awarded a posthumous V.C.

About this time, two of my sappers lost their lives in a most unfortunate way. Firewood was very short, and my men had orders to catch any driftwood floating down. Two of them saw a harmless looking piece of wood coming along, and jumped down into a boat and pulled it out; they had the surprise of their lives; it was the float of a small home-made Turkish mine, which partially detonated, killing them both, but without doing any serious damage to the bridge. The Turks were sending a number of mines down about this time, but I do not remember hearing of any other damage resulting.

It was shortly after Kut fell that the bridge finally received its *coup de grace*; the skipper of a large river steamer, with the usual barges lashed alongside, was caught napping by the current, and was carried broadside on to the centre of the bridge, where the bigger boats were; for a few seconds the bridge held and its boats seemed almost to climb on to the barges lashed to the steamer; then,

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with reports like guns, the bridge gave, the 3-in. steel cables either breaking or pulling clean away from their boats, and the steamer drifted down-stream surrounded by more than a hundred yards of the bridge. The skipper of this ship had come from the Yukon: he was relieved of his command and consigned to a much warmer climate. Material was not available to rebuild it, and, with the fall of Kut, there seemed no necessity for it: so permission was asked to dismantle it completely. This was shortly afterwards given, and the bridge was moved down to Shaikh Saad, which now became the advanced base, and re-erected at a much narrower and more sheltered site.

Shaikh Saad.—The summer of 1916 was spent at Shaikh Saad, and I propose at this point to describe how river traffic was dealt with.

Definite hours were published in orders during which the bridge would be open for road traffic and for river traffic. In this connection, the expression "the bridge will be open" is by itself entirely ambiguous, and in the early days caused frequent misunderstandings. Another cause of confusion, which took a long time to be appreciated, was the fact that it took a considerable time to open and close the bridge. Dealing with a large cut in a bridge of boats of local materials is a very different matter to forming double cut with pontoon equipment.

Cuts.—This leads me on to the question of cuts. Their position in the bridge depended on the requirements of navigation, the ruling point usually being the channel and course of traffic coming down with the stream. Their width was governed by that of a large river steamer with a barge lashed on each side, which amounted to 120 ft., and cuts of 300 ft. were often made. This was either done by breaking the portion concerned into rafts of two or three boats or by swinging the entire cut. In a strong current, breaking up into rafts was found to be the only practicable method, though swinging was adopted whenever the conditions permitted. On two occasions I have seen the swung portion break away when opened, and depart downstream. To enable the swung portion to be closed rapidly by one cable from the end, it had to be very strongly braced between boats. In the absence of submarine cable, signal wires were often laid over a bridge, when special contact arrangements had to be made at the cut.

Signalling.—Another most important point is an efficient method of signalling to shipping coming downstream, to show whether they may proceed or not. The rule was that, unless shipping could see the "all clear" signal, they must anchor well above the bridge; the "all clear" signal consisted of a large cone by day and four lamps by night hoisted on a tall mast; this arrangement is much safer than any danger signals which, in a storm, are liable

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to be blown down or blown out. The ends of the cut were, of course, also well lighted at night with red lamps.

Shipping coming downstream had right of way over any shipping coming up, though I have known two large river steamers actually pass in the cut. On another occasion I saw a naval gunboat drift through broadside on !

Anchors.—When we left Orah it was found impossible to recover the anchors, though a river steamer with steam anchor winch was used. To prevent a recurrence of their loss, should the bridge again shortly be moved, they were periodically raised. It was difficult to judge how often to lift them to ensure that they were not irrevocably imbedded in the alluvial mud, and yet retained sufficient holding power to meet possible floods or collisions.

Mobile Bridging Train.—I now turn to an entirely new phase. One of the many preparations, which were initiated in the summer of 1916 with a view to turning the Turks out of the Sannaiyat position and recapturing Kut, was the formation of a mobile bridging train. Hitherto no land transport had been provided and a bridging train had depended for mobility on tugs, supplied as required.

Pontoons and Superstructure.—It was decided that pontoons and superstructure should be of English pattern and they were accordingly ordered from home. So far all pontoons and superstructure had been of the Indian pattern, and I propose, before going on, to describe them generally and point out where they failed. The original pre war Indian pontoon was a bipartite pontoon made of copper, and was a thoroughly serviceable article, its only drawback being its weight and its cumbersome method of joining up sections. The same may be said of the original superstructure ; the road-bearers, for instance, were not tapered and not hollowed out, and were consequently much heavier than the British pattern. But when Indian factories were asked to turn out large numbers, copper for the pontoons had to be given up and sheet-iron substituted, and the workmanship and quality of both pontoons and superstructure reached a very low ebb. Bow and stern sections of pontoons were not interchangeable ; as soon as one leak was patched they started another ; and leaks were extraordinarily troublesome to mend. Road-bearers and chesses were made of inferior wood, and often broke under very small loads or warped to such an extent as to be unusable in bridge.

Transport.—The next point considered was the method of transport. It was thought that the English pattern pontoon wagon would be too heavy for the roadless plains of the country, often feet deep in dust or mud : the Indian pattern wagon was twice the weight and intended for bullock draught, the slowest known form of transport. Experiments were therefore carried out with the Indian A.T. cart—a very light two-wheeled cart with pole draught

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for two small mules: a longer axle was fitted, which enabled one section of a pontoon to fit down between the wheels, and a longer pole was necessary to keep the haunches of the mules clear of the front end of the pontoon section. With these alterations, and a few minor fittings, a thoroughly serviceable cart was evolved, which could go practically anywhere that the ordinary A.T. cart could go, and that is quite the most handy form of wheeled transport. Its unusually wide track and length of pole were its only drawbacks. The cart was equally serviceable for carrying loads of supplies when required, and, in a country like Mesopotamia, that was a really serious consideration. The superstructure, anchors and cables were to be carried on ordinary G.S. wagons. Transport was arranged for 500 yards of bridge, *i.e.*, 200 pontoon carts and 56 G.S. wagons, involving 900 animals and 600 driver personnel.

Arab Village.—The bridging train I commanded had the good fortune to be selected for conversion into the Mobile Bridging Train, as it was officially called, and we were moved up to Arab Village.

Wadi Bridge.—Soon after this move the arrival of the rainy season was ushered in by a very heavy storm in the Pusht-i-Kuh range, clearly visible to us sixty miles away in the plains below. There was a bridge of boats and Weldon trestles across the Wadi which comes down from these hills. My successor at Shaikh Saad realized that this bridge might be in danger, and he wired to the O.C. battalion posted there asking "if the bridge was causing him anxiety"; the reply he received was very much to the point; it ran, "Bridge causing no anxiety whatever, it was completely washed away half an hour ago." The spate apparently came down in a 10ft. wall of water, and swept everything before it.

I was told to do something about it. A floating bridge was obviously out of the question, but we had available a large amount of 3-in. steel cable, intended for use with anchors. The span was 105 or 120 ft. and I rigged up a tension bridge, using pontoon superstructure for the roadway. Material for the piers and anchorages was obtained by breaking up a wrecked *mahela*. It was calculated to carry a 12-pdr. man-handled across: a year or so later I was asked by wire how it could best be strengthened to take lorries. I was gratified to hear it was still standing but felt perfectly justified in replying, "Pull it down and build another."

Secrecy.—Sir Stanley Maude had, in the meantime, taken over command, and he was a great man for surprise. Amongst other things he wanted the formation of this mobile bridging train to come as a surprise to the Turks. The pontoons, therefore, came up by river, either towed or on barges: the transport marched all the way by road, carrying supplies, and looking to the casual observer every bit like the ordinary A.T. cart. On arrival at Arab Village

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the carts were not allowed near the pontoons. My men, therefore, had no practice in packing and unpacking. It was only the day operations started that we were permitted to load up. The full number of carts had not then arrived, and a few pontoons had to be carried on G.S. wagons, a most unwieldy load. A G.S. wagon, on the other hand, is a surprisingly suitable form of transport for a couple of bays of superstructure of light bridge.

A general description of the operations which followed, with particular reference to bridging work, can be seen in the August number of the *R.U.S.I. Journal*, and I propose to-night to touch on certain details, technical and otherwise, not there mentioned.

Operations Round Kut.—Bridging the Hai was a very simple matter at the start; in fact, no bridge was really essential, as it consisted of a succession of deep pools alternating with dry stretches. However, the water-level in the Tigris rose soon after and converted the Hai into a respectable river 150 to 200 yards wide, which gave us plenty of opportunity to practise for the major operation of forcing the passage of the Tigris, which one realized was in store.

The first attempt to get across some 15 miles above Kut depended for success entirely on surprise and the complete absence of opposition. When these conditions were found to be lacking, the attempt was soon abandoned, but not before all concerned had received very valuable experience.

General Maude then conceived the idea of imitating the River Clyde episode at the Dardanelles. His intention was to send up motor lighters, of which a number had come out from Gallipoli: they were to run the gauntlet of Sannaiyat and the back defences, as far as Kut, where they were to turn into the Hai. Here they were to pick up landing parties and then dash out, cross the river and beach themselves on the other bank. It is characteristic of the man that he took extraordinary precautions to keep this idea to himself. Soundings were necessary round the mouth of the Hai to see if the scheme was practicable, so he summoned the Bridging Train commander to a private interview. I was much surprised at being sent for, and still more so at being sworn to absolute secrecy, being particularly warned against whispering a word of what he was going to say to even the most senior members of his staff. He told me what he wanted and added that my reports were to be private letters addressed to him personally by name. Paddling about in a pontoon for two or three nights with the Turks on one bank and our own troops on the other was no joke, and though the river was 400 to 600 yards wide, I was not sorry when I was in a position to report the scheme impracticable. He then told me to take every opportunity of reconnoitring the river for a bridge.

Pontoons for Live-Stock.—Pontoons had other uses than mere bridging. On one occasion I had to send a dozen out with the

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Cavalry Division on a raid: they came back filled with a couple of dozen sheep. It was not for a fortnight that any enquiries were made for these sheep, when I had to confess we had eaten half of them. However, it was about Christmas time, so no serious notice was taken of it. One pontoon section I had fitted with a movable wire-covering and used as a mobile hen-coop: consequently I was never short of fresh eggs, but I always dreaded this pontoon being launched, in the hurry of the moment, complete with hens.

Shumran.—When the Turks were finally cleared from the right bank, I was told to reconnoitre the Shumran bend. It was possible to get up to the river bund without difficulty at any hour, but it was not so easy to measure the width with any accuracy, particularly as special orders had been given not to attract undue attention to the locality. The 3-in. to 1-mile map, based on aeroplane photographs, gave one a good idea, but it was very desirable to check it, and particularly to note the effect of a possible flood. I took very good care that my estimates, based on prismatic compass readings, were on the right side. The site of the old Turkish boat bridge was finally abandoned in favour of the apex of the bend, which was by far the most suitable place tactically and also the narrowest. I made it out to be 340 yards. A pocket sextant is invaluable for accurate measurements of this sort.

The ferrying arrangements were kept quite separate from the bridging and were worked out to the last detail and carefully rehearsed by night on the Hai. Only pontoons were used.

Turning to the technicalities of the bridge, it was made by forming up. Unlimited labour was available, overcoming the objection of having to carry baulks and chesses two or three hundred yards; and it was also considered safer, in view of the strong flood running and of the inevitable interference from hostile artillery. For anchor work two motor launches, carried on Indian bullock-drawn pontoon wagons, had been provided; these were successfully got up and launched and proved invaluable. The rate of construction was entirely controlled by the time required to get out the anchors. The current was between five and six knots and the handling of the launches was a very delicate matter: one launch did foul the bridge, and complete disaster was narrowly averted. In view of the flood running, all the downstream anchors were sacrificed, the anchors themselves were used in kedge upstream and the cables to lengthen the upstream ones. Every second pontoon thus had a 1-cwt. anchor with a ½-cwt. anchor in kedge at the end of 400 ft. of 3-in. cable. As a result of these precautions no anchors seriously dragged, in spite of a tendency to do so when first cast.

Further details of these operations can, as I have said, be found in the August number of the *R.U.S.I. Journal*, and I will therefore now pass on.

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Dialah.—I was not personally present at the crossing of the Dialah, but I cannot pass it by without notice, as it was quite one of the most heroic episodes in the whole campaign in Mesopotamia. The Turks were in retreat, and it was therefore decided to act boldly and try to rush the crossing without any adequate preparations, which meant loss of time. The first night pontoons appear to have been launched successively at more or less the same spot and each met the same fate—every man in them being shot down ; the river was only 100 to 120 yards broad and no proper covering fire could be arranged in the time. The second night, under cover of a local barrage on the opposite bank, the first pontoons got across, but when the barrage had to lift, succeeding pontoons met the same fate as on the previous night and their occupants were exterminated. But some sixty men of the Loyals were established, and held out under heroic conditions for 24 hours until the crossing was finally effected. This was largely due to the threat of the Cavalry Division and 1st Corps, which had been moved over to the right bank at Bawi, partly by steamer ferry and partly by a pontoon bridge which had been towed upriver from Arab Village. On this third night General Maude put into practice the River Clyde stunt he had considered before. Two armed motor lighters carrying 500 men started off to run ashore half a mile above the mouth of the Dialah. They grounded on the sandbanks in the Tigris, but in any case they would have been too late. The threat on the right bank had made the Turks move. The actual bridge then built over the Dialah near its mouth was an ordinary pontoon bridge and needs no comment.

Baghdad.—The Turks destroyed their bridge of boats in Baghdad before evacuating the place. The pontoon bridge from Bawi was towed up and put across at the old bridge site—the narrowest point of the river. My mobile bridging train marched up from Shumran and we put a bridge across at the new advanced base just below Baghdad.

These bridges were later replaced by two, known as the North and South Bridges. The North Bridge was made of large open iron pontoons sent out from India. The South Bridge was formed of dredger pontoons supplemented by a few locally made bridge boats. These dredger pontoons had previously been used in a bridge over the Euphrates at Gurmut Ali, where they were anchored end on right across the current, violating all the rules for floating bridges ; this was done in the absence of sufficient material for any other method, and proved satisfactory. A 60-pdr. could be man-handled across the South Bridge. It sank once during construction and was completely destroyed later, when it was replaced by the Maude bridge, which met a similar fate in the floods this spring. Full details of this fine bridge can be found in the volume *With the Inland Water Transport in Mesopotamia.*

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We stayed at Baghdad for a fortnight or three weeks, and were then ordered forward to take part in the operations for the capture of Samarrah.

Two incidents in connection with this move are, I think, of interest. Our orders came by clear line telegram one morning about ten o'clock to march that night at ten o'clock to a place some 20 miles ahead. The bridge was across the river and in use. I arranged my time-table for dismantling the bridge and loading up so as to allow my men three hours for rest and food before marching. About six o'clock in the evening I received another wire telling me not to dismantle the bridge until a certain brigade of artillery had crossed. By this time the bridge was completely dismantled, and loading up was nearly completed. When I telephoned to point this out I was informed that ten o'clock was the time ordered for my march. The time required to dismantle 300 yards of pontoon bridge and load it on to transport, not to mention the fatigue caused to the men, had once again been overlooked entirely.

During the day I had taken the precaution to ask for the latest map. It seemed from it that if we stuck to the railway during the night we should find ourselves near the river in the morning. Instead, however, there was no sign of the river or of any other water; we therefore struck north and had some five miles to march to the river, making 25 miles in all. The map was all wrong. It was the same map which had led to our turning the Turkish position at Mushaidieh three weeks earlier; the Turks did not anticipate such a wide detour from the river, and, in fact, there was no intention of making it.

After a halt for a day or two at Fort Kermea, we marched on to Beled. On the way we were caught by very heavy rain, the ground was completely flooded and we were able to water the mules as they stood. The only way we could get on again was by temporarily abandoning half our carts and wagons and double-teaming the other half the remaining four miles to camp, and then sending back the double teams.

Sinijah.—From Beled we moved down to the Tigris at Sinijah and put a bridge across there. This place practically marks the limit of the alluvial deposit, and, from here on, the bed of the river consists of shingle with occasional rocks. I particularly remember this bridge for two reasons. To start with, every road-bearer and chess was in use, and there was literally not a single one spare; wagons were, therefore, particularly carefully scrutinized before crossing, and I recall bitter complaints from the gunners at being told to throw off tents and grain from their ammunition wagons. Then the night it was done we got warning that the Turks had set fire to two ammunition barges which they could not take away upstream; that they were adrift and floating down towards the

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bridge. We opened a cut and sent a tug up. The latter piled itself up on the shingle almost at once. Fortunately the barges too soon stranded.

Samarrah.—As soon as Samarrah was occupied at the end of April, 1917, the bridge was moved up and put across there, and there it remained in peace for the next eight months. The site chosen was the most suitable during the low-water season, but it was evident that it would have to be abandoned during the floods, for which reason a site 500 yards wide was selected and prepared. But when the floods finally came, it was found impossible to keep a pontoon bridge afloat, and it was replaced by a steamer ferry.

At Samarrah there was a difference of 23 ft. between low and high-water marks. Floods were due either to heavy rain or to melting snow in Asia Minor; the former caused possibly the more sudden flood, but the latter was responsible for the highest floods. The water occasionally rose 8 ft. in the 24 hours. Elaborate flood-warning arrangements were initiated, but were of little value to the bridge furthest upstream, as our enemies the Turks would not co-operate !

During this summer, in addition to the main pontoon bridge, a flying bridge was maintained at another point. The raft was of the ordinary four-pontoon type and worked on a 3-in. steel rope, suspended between a tripod on the higher bank and a length of the Baghdad railway up-ended on the other bank, which was practically water-level.

This flying bridge was later replaced by a bridge of half-pontoons some 200 yards long. It did useful work, but is not a satisfactory form of bridge.

A handrail was made of oars fitting into hoops on the kelson and held by the rack-lashing and carrying spare anchor cable fixed by clove hitches. It was of considerable moral value, and its flimsiness was an advantage, as it did not complicate cutting a wagon clear, if the bridge itself was in danger after an accident, as often happened in a strong current.

The 60-pdr. guns and 6-in. howitzers had also to be moved across occasionally. This was done on a standard pattern 60-pdr. raft, moved across below the main bridge by ropes, pulled by sappers walking across the bridge.

The number of baulks in bridge was brought up to nine per bay to enable armoured cars to cross freely, but transport was only provided for seven baulks per bay.

The powers that be were very worried about mines, and a buoyed 3-in. steel cable was therefore maintained, with considerable difficulty, across the river above the upper bridge. The Turks tried to send mines down on several occasions. They were contact mines of the latest type, but our protection lay in the windings of the river and

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the many banks in its course. None ever reached the so-called mine-boom; though I was sent out on two or three occasions to blow up mines stranded upstream.

During the summer, pontoon wagons arrived from England to replace G.S. wagons for carrying superstructure. All the time our sappers were kept hard at work keeping pontoons in repair. These were of the Mark II pattern and were never designed for continual use of this nature, and, though they lasted well if always in the water, if taken out after a long immersion and required again two or three days later, they were useless. Waterproof canvas, india-rubber solution and marine glue were in great demand: the planking, too, often warped seriously and had to be replaced. Various notes on the pontoon equipment based on experience in this country were published in the *R.E. Journal* for November, 1921.

By this time, arrangements and regulations for the control of traffic across the bridge had been elaborated in considerable detail. A detachment of 1 N.C.O. and 6 men of the Military Police were permanently attached to the Bridging Train, and two of their number were always on duty. A sapper maintenance detachment was also on permanent duty, consisting of 2 N.C.O.'s, together with three sappers per hundred yards of bridge, thus allowing of one sapper always on duty in each hundred yards of bridge. When artillery crossed, an officer of the bridging train was always on duty, and extra sappers, to allow of one in every other pontoon: any breakages were therefore promptly detected: a breakdown gang with drag-ropes, knives, and hand-axes were kept in readiness on the bank. One pontoon was always ready to be manned as a lifeboat, and often one of the launches was also in immediate readiness. I was fortunate never to lose a gun, but one or two ammunition and ambulance wagons were lost, and A.T. carts on numerous occasions, owing to the innate foolishness of the mule. The one ambition of many mules seemed to be to push its pair off the bridge, and a regular pushing match would ensue.

There was very good fishing at Samarrah. One of my warrant officers caught a 98-pdr. Tigris salmon on a rod and line: it took 1½ hours to land. A 132-pdr. was pulled out by one of my men on a ground line. The Arabs used to catch them by throwing in a loose bait containing opium: they then swam out and caught the drugged fish which came to the surface with their hands. Some of those they missed were often picked out as they floated through the bridge by my men.

Euphrates.—In January, 1918, we were suddenly ordered to march back to Baghdad, leaving all our actual pontoon material behind. At Baghdad we drew an entirely new outfit from the Engineer Field Park at the Advanced Base, and then marched over

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to the Euphrates, where operations were in preparation to round up the Turkish force.

However, we did little beyond building bridges which were never used, and thoroughly frightening the Turks. One of their aeroplanes observed us on the march and mistook our column of more than two miles in length for substantial reinforcements of field artillery; the Turks withdrew their advanced posts next day.

The Euphrates was much like the Tigris up to Hit, where it emerged on the alluvial plain. Above Hit it ran in a wide rocky bed, much cut up by stone weirs built out for water-power purposes during the low-water season.

We spent the summer of 1918 just above Hit, and the only incident of note was the complete swamping of the bridge—some 300 yds. long—in a sudden violent squall. It sank and was swept away *en bloc*. Pontoons were scattered miles down the river, but only about half-a-dozen were never recovered, though all were much damaged.

Life at Hit was dominated by the bitumen springs which belched out sulphuretted hydrogen and made things almost unbearable in certain winds.

Tigris.—We marched back to the Tigris in September in time for the final push just before the Armistice. For this we were reinforced by half the other mobile bridging train, which had been formed some time before, giving me 750 yds. of light pontoon bridge on wheels to play with.

During these operations we had our hands full and bridged the Tigris at Baiji and Fathah, the Lesser Zab at its mouth, and finally a bridge of half pontoons at Hadraniyah, where the two cavalry brigades had previously forded the river, and cut off the Turks. All these bridges were in position at once.

Fording the river here was a wonderful feat: the 18-pdrs., with which the horse artillery were specially armed, completely disappeared from view in the middle of the ford, which was almost a rapid. A number of men and horses were drowned, and one gun washed away but recovered by a subaltern of mine some days later. However, the Turks thought the river absolutely unfordable and were completely surprised. It was a great "finale" to the campaign.

Conclusion.—In conclusion there are two things I should like to mention. The first is that one bridge over the Dialah was constructed of *gufas*—the circular boat, made of reeds and bitumen, dating from the days of the Ark. Each pier consisted of two *gufas* held in correct position by a wooden frame. The other is that the Grand Stand at the Baghdad Racecourse was made throughout of Weldon trestles and pontoon superstructure, and is evidence that they, too, like pontoons themselves, have other uses than mere bridging.

NOTE.—*The lecture was illustrated throughout by lantern slides.*

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UNARMED DEFENCE.

By A THIRD SAPPER OFFICER.

THE article by " Two Sapper Officers " under the above title in the June number of the *R.E. Journal* calls for some comment. It is difficult to understand the aim of the writers in impressing on their brother officers the somewhat obvious fact that it is not a " sound policy of defence " to allow another nation to invade and occupy one's country. In fact, this can hardly be considered a policy of defence at all. Though many will disagree with the view that, among civilized states, armed invasion and occupation can ever confer any lasting benefit on the invader, however ruthless he may be, yet it is obvious that, even though quite profitless to the invader, this is an extremely unpleasant and humiliating state of affairs for the invaded ; and the unpleasantness increases in proportion to the ruthlessness of the invader. No nation's policy, therefore, deserves the name of " defence," unless it aims at preventing armed occupation of its territory. This may surely be taken as the chief object of national defence.

But there seems to be more implied in the two writers' conclusion than would appear from this literal interpretation. In the absence of any qualification of their conclusion that " disarmament as a policy of defence is unsound," it must be assumed that they imply opposition also to the proposal for general disarmament, which holds a foremost place to-day in the field of international politics. This may be a wrong inference, but it is one that will be naturally drawn from this conclusion.

Now, the idea of general disarmament, widely advocated to-day, is quite a different matter from the partial and one-sided disarmament, specifically dealt with by the two writers. The latter policy would be suicidal folly, but it is equally foolish to consider the former merely as an impracticable theory of idealistic cranks.

In these days, all civilized nations ostensibly maintain their armed forces solely for defence. The average civilized individual is not wantonly aggressive by nature ; he believes in the doctrine of " live and let live," and has no natural desire to invade a neighbouring country and slaughter its inhabitants. Apart from moral and ethical considerations, he stands to gain nothing personally by such action, but stands to lose a great deal, and self-interest is a very powerful factor in the conduct both of individuals and states. The

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very existence of law and order in all civilized communities supports the assumption that the general inclination of civilized mankind is towards this peaceful condition of affairs. It follows, therefore, that there should be no fear of aggression among civilized states, and, therefore, no need of armed defence to meet it.

Unfortunately, under present conditions, the wishes and common-sense of the average intelligent individual cannot always exert sufficient influence on the national policy. A certain number of powerful and unscrupulous men in any country may consider that they stand to gain considerably, by an access of power or wealth, from aggressive action against some other state, and they may be quite prepared to force their country into such action, to gratify their ambitions. The policy of Germany before the war is an obvious example of this condition of affairs; and, in this case, the policy had been so long and elaborately planned that the rising generation had been systematically educated, against their natural inclinations, to believe to some extent in the aggressive attitude and amazing self-conceit of their rulers; any teachers who attempted to oppose this deliberate educational policy promptly vanished into obscurity.

Under these circumstances, every nation is at present forced to face the possibility of aggression by its neighbours, and to prepare its defences accordingly. A defence policy of some description being necessary, it remains to determine what form that policy shall take. Before the late war, the commonly accepted form was to ensure one's own superiority in armed strength over any likely aggressor, or group of aggressors, assisted if necessary by alliances or understandings with other governments who happened at the moment to be friendly. This led logically and inevitably to ever-increasing competition in armaments. As this policy began to prove such a financial burden to the states concerned, attempts were made from time to time, by partial arrangements and understandings, to set some limit to the progress of this ruinous competition; but the underlying conditions being as they were, these arrangements could never hope to be more than mere temporary palliatives.

The result of this universal policy is very recent history, and needs no comment, except that it very obviously did not lead to the slightest natural benefit to any of the states chiefly concerned and, if persisted in after this recent experience of its inevitable result, will assuredly prove vastly more disastrous in the not very distant future. It was generally hoped, and quite confidently believed, when fighting ceased, that the "war to end war" had exposed the futility of this method of preserving peace, and would finally put a stop to this suicidal policy. Up till now, these hopes have not been fulfilled. It seems as if the recent cataclysm has taught Europe no lessons of real value, and that the race for supremacy has already begun again. It is urgently necessary, therefore, to devise some

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alternative to this worn-out policy, in the hope that it is not beyond the wit of man to invent some better system for the regulation of international affairs.

Let us, then, consider what is the alternative to cut-throat competition in armaments, and to the essentially unstable method of preserving peace, known as the Balance of Power. For it is obvious that this Balance of Power must, from its very nature, be as essentially unstable as the mechanical balance from which it derives its name, since any small increase of power on either side will automatically endanger its stability.

I do not now, as my forefathers did, walk about in public armed to the teeth, to defeat any blood-thirsty ruffian who demands my money or my life. I rely on the force of public opinion, in support of law and order, and personified in a force of police, to lay such ruffians by the heels, and make the country safe for peaceable citizens to live in. And in return for this protection that is afforded to me, I undertake, firstly, not to walk about armed to the teeth, myself a menace to other peaceable folk, and secondly, to assist the police when required in the execution of their office.

Undoubtedly, the most far-reaching result of the late war has been to make it clear to numbers of thinking men throughout the world, that the only reasonable method of keeping aggressive and bloodthirsty nations in check is by concerted action on the part of all peaceable nations directed towards the maintenance of peace. It may be objected that this method was tried after the Napoleonic wars, and failed. But, as we are pleased to think, civilization has progressed since that time, and there can be no doubt that, owing to the far greater scale of the last war, and to the fact that whole nations, and not merely professional armies, were engaged, the general desire for peace to-day is very much stronger than it ever was before. It should also be remembered that this previous attempt failed, principally from the fact that the new general alliance or league made the fatal mistake of attempting to interfere in the purely domestic concerns of its constituent parts.

But, as in the case of an individual, if a nation wishes to obtain the protection and support of other peaceable nations, when it is threatened or attacked, it must comply with two conditions. Firstly, it must not arm itself to such an extent as to be itself a menace to the nations whose support it desires; and secondly, it must be prepared to give its own support whenever required to the suppression of aggressors and the maintenance of law and order. To fulfil the second obligation, armed forces must be maintained; but to comply with the first condition, they must only be of such a strength as is approved by the other parties to the agreement. This idea is the whole basis of the present proposal for a universal limitation of armaments, coupled with a general treaty of mutual

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guarantee against aggression, a proposal which is one of the most important results to date of the establishment by the Treaty of Versailles of the League of Nations.

Now, in some quarters, the bare mention of the League of Nations is a signal for an outburst of contempt and abuse, while in other quarters the subject is regarded merely with apathy and indifference, as being of no practical importance in present-day affairs. It is, perhaps, somewhat natural that this new idea should not at first find much support among soldiers, as our whole energies and training are directed towards preparation for war, which it is the primary object of the League to prevent. But it should be remembered that our country, by its ratification of the Treaty of Versailles, is definitely pledged to the League's support, and it is worthy of note that it has the active support of such eminent soldiers as, for example, Sir Frederick Maurice, and the present Chief of the Imperial General Staff. And, if the subject is regarded from a rather broader point of view, it is apparent that there is no real antagonism between the object of our army, and that of the League.

Very few officers will be found to maintain that our Army exists for aggressive action and the conquest of peaceable states. The whole policy of our country is essentially opposed to such use of its armed forces, which are maintained solely for the defence of our territory, honour and interests against aggression. Even such a distinguished opponent of the League as the late Field-Marshal Sir Henry Wilson, strongly urged that the primary object of our army should be, not to win a war, but to prevent the outbreak of war; in other words, to preserve peace. The primary reason for the existence of most armies and of the League of Nations is, therefore, in essence the same, namely, to preserve the independence and territorial integrity of states, and to restrain, if necessary, by force, any aggressive nation that attempts to disturb that state of affairs; and armies are the tools by which, in the last resort, this purpose must be enforced. That being so, there seems no reason why the League should not command the support of all soldiers, who give any thought to international affairs.

It is objected by many that the League in its present form is incapable, owing to various defects, of attaining the objects for which it exists. Admittedly, the machine is imperfect, as are all new institutions until they have had time to learn from experience, and perfect their organization accordingly. But its constitution is elastic, and susceptible of unlimited adjustment and improvement, given only the spirit of determination to make it work. Those, moreover, who would abolish it forthwith on this ground, never suggest any practical alternative to take its place, so that their criticism takes the easy and useless form of pure destruction.

With those who oppose the League on the ground that war is not

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an evil, which it is the duty of progressive civilization to root out but actually a benefit to the human race, it is useless to reason. Their mentality and outlook on life are entirely different from that of the normal man, and they are of a type whose ideals have made little progress from those of its primitive ancestors who lived in caves. And though many of them may call themselves Christians, their view proves that they have not the slightest conception of the meaning of the Christian idea. Moreover, Western civilization itself has been put to the severest test by the recent war, and it seems probable that a future war, on the same or a greater scale, with the increased powers of destruction which the rapid strides of scientific invention will afford, would destroy our Western civilization for good. It is to be hoped, therefore, that those who honestly regard war as a boon to mankind, are in a negligible minority; and this hope gains some support from the generally observed fact that it is only as a last resort, when all other arguments have failed, that opposition to the League takes this extraordinary form.

If, then, the League of Nations is accepted as essential to the true progress of mankind, the policy of limited armaments and mutual guarantee must be accepted, too. For it is on the success or failure of that policy that the League will stand or fall. It clearly cannot continue to exist in the atmosphere of hostility and distrust, inseparable from the old policy of competitive armaments.

In short, while disarmament by isolated states, as their policy of defence, is obviously unsound, it is equally true that the general limitation of armaments, with mutual guarantees, affords the only real hope of the future preservation of peace, and is in the end the soundest policy of defence for all concerned.

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THE "LOUD-SPEAKER."

By "METRE."

A NOVEL feature of the R E. Sports Meeting at Aldershot on May 26th, 1923, was the employment of the loud-speaking telephone system in place of the traditional megaphone (with brazen-lunged N.C.O. attached) for collecting competitors and making announcements. Anyone who has run regimental sports knows the difficulty of assembling competitors; whatever elaborate arrangements have been made, recourse to the megaphone is inevitable, and as for the announcement of winners, etc., the result is usually unintelligible, and rouses a feeling of unreasoning animosity against the unfortunate megaphonist in particular, and the management in general.

These petty annoyances were completely abolished by the use of the loud-speaker. Competitors were coaxed to appear and results announced with a minimum of effort and a maximum of effect. The identity of the speaker is even more easily recognisable than in the case of the ordinary telephone.

The actual instrument used was the No. 3 size of the Public Address System, made by the Western Electric Company, by whom the demonstration was given. This is the smallest of three sizes, the largest of which makes it possible to address with ease and clarity a crowd of 200,000 people. A similar instrument was installed at Olympia, where the music from a single band was transmitted to the five separate halls of the Ideal Homes Exhibition.

The outfit, which was very compact and portable, consisted of a special table microphone with a thermionic amplifier, having accumulator batteries of 12 and 250 volts, and three loud-speaking projectors hung from the Events board outside the tent. Two of the projectors, at an angle of about 60° one to the other, were directed towards the principal enclosures, while the third was directed backwards over the field towards the dressing tents. The microphone, amplifier and accumulator were installed inside the Committee tent. (FIG. 1.)

The microphone, which is similar to that used in the broadcasting of opera, etc., has a metallic diaphragm mounted under such tension that its lowest natural frequency of vibration is above the upper limit of audibility. On each side of the diaphragm is a microphone button, these buttons and the diaphragm being connected to a

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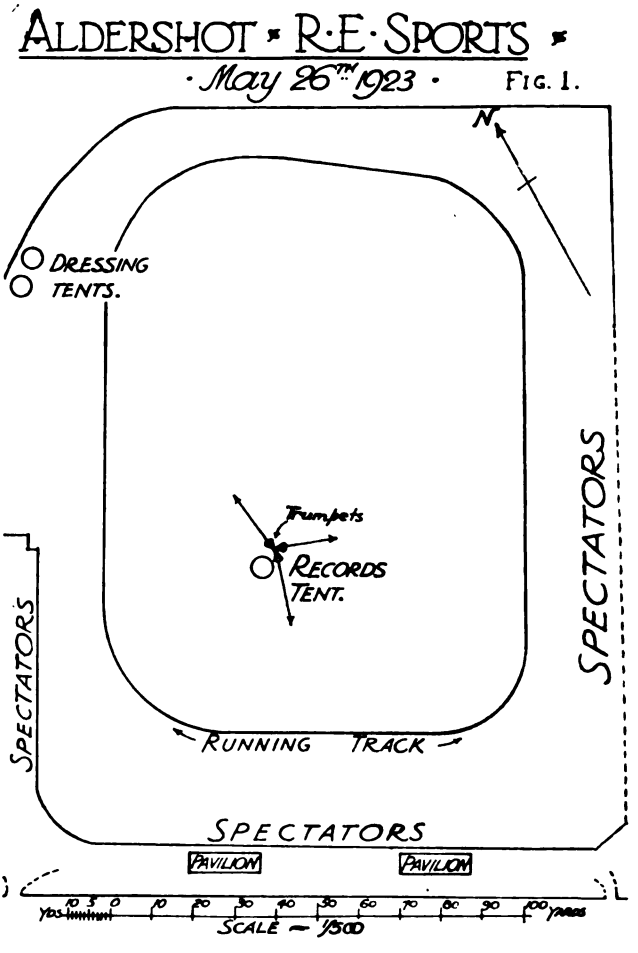

FIG. 1.

centre-tapped transformer so that in the two microphonic systems the effects of normal diaphragm vibration are additive. The whole microphone is suspended on springs in an outer case so as to protect the microphone from casual mechanical vibration.

The microphone controls (through a tapped transformer which provides for a wide variation in amplification) the input of a three-stage thermionic amplifier, transformer-coupled throughout, of which the last stages consist of a pair of triodes coupled in a "push-pull" circuit, a device which minimizes distortion due to curvature of the triode characteristics. The four triodes used in this amplifier were of the Western Electric coated-filament type, which, although not so familiar in this country as the tungsten-filamented tubes, have remarkably good characteristics and life.

The loud-speaking receivers fitted to the projectors are of the "moving coil" type, in which the coils carrying the operating

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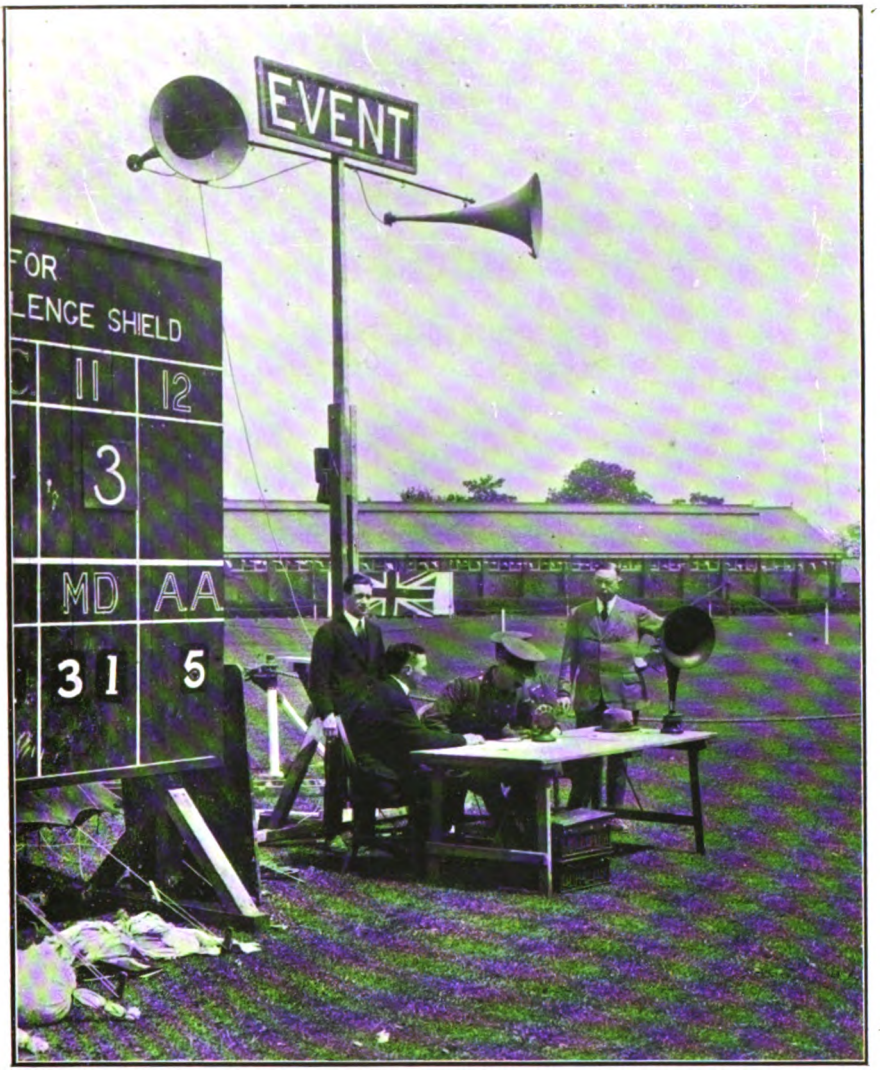
THE "LOUD-SPEAKER."



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current move in the field of a permanent magnet. The controlling force is derived from a stiff metallic spring, while the diaphragm is a corrugated disc of bakerlized linen. A skeleton diagram of connections is shown in FIG. 2.

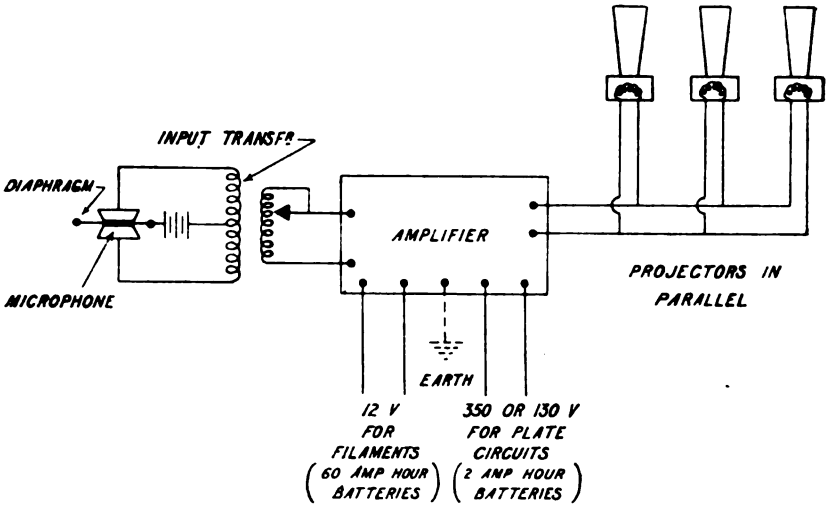

FIG. 2.

The system, while providing great amplification, has been designed specifically to reduce the distortion which is the inherent defect of acoustic amplifiers and their accessories, and considerable success has been attained in this direction.

The extreme sensitivity of the instrument was strikingly demonstrated in the tests preceding the actual sports meeting, when the rustling of a programme in the Committee tent was clearly audible at every point on the ground. In actual use, announcements made by an officer speaking in a normal manner about a foot from the microphone were clearly heard above the music of the band, and even in the public roadways outside the sports ground.

Altogether the demonstration was most interesting and contributed in no small degree to the success of the meeting.

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LIEUT.-COLONEL WILLIAM CUNINGHAME OF ENTERKINE.

By F.E.G.S.

THE Royal Engineers Museum has recently received from Major-General R. Bannatine-Allason, Colonel-Commandant R.H.A., the gift of a valuable collection of documents selected from among the papers of his ancestor, known to readers of *The History of the Corps of Royal Engineers* as Lieut.-Colonel W. Cunningham, who achieved distinction by his magnanimity and gallantry in the unfortunate defence of Minorca in 1756, and died at Guadelupe in 1759. Pieced together, these documents tell the tale of a most strenuous and active life which, while it lasted, can hardly be matched in the long history of the Corps. Of his early life mention is found in a letter dated June 25th, 1742, in which he says, "From my entering into the world till February, 1740–1 I served as Volunteer and Officer in the Dutch Service," and elsewhere he says that during the first seven years of his service he was abroad in Flanders, France and Germany.

His first service under the British flag was the expedition which sailed for the West Indies in August, 1740, under Lord Cathcart, who unfortunately died at Dominica, leaving the command in the hands of the incapable General Wentworth. The expedition, after visiting Jamaica, and joining the fleet of Admiral Vernon, disembarked early in March, 1741, near Boca Chica in the island of Cuba, with the intention of taking Carthagena. After some delay Boca Chica was captured without difficulty, but in a letter written later in the year, after he had seen the gazette—probably written by the Admiral—describing the operation, Cuninghame complains that "the taking of the place is attributed to causes that no way tended to that Effect, and entirely omits mentioning General Wentworth or those who served under him and contributed entirely by the construction of the 20-gun Fascine battery and oy^r works there carried on to ye surrender." This was followed by the unfortunate and costly attack on Fort St. Lazare, covering Carthagena, the failure of which is attributed by Mr. Fortescue to the unskilfulness of the Engineers and their failure to plant a battery on a neighbouring hill commanding the Fort. Some light is thrown on this by a dispute which took place some months afterwards between the

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General and his Chief Engineer, Mr. Armstrong, in Cuninghame's presence. It arose out of a remark by the General that for Engineers "he had no Coehorns or Vaubans, but gentlemen of very good capacity who only wanted experience to complete them in their business." On Armstrong objecting, the General said, "You yourself owned to me when you was asked if you could raise a battery against St. Lazare, of which duty you excused yourself and said you could not do. . . . Did you not say when you was call^{d} before the Council of War held at La Quinta, when ask^{d} if you cou^{d} raise a battery, that you desir^{d} till next day to consider of it, that we agreed to give you time to reconnoitre and determine. That next day when I met you at the advanced guard you was standing wth your arms a Kimbo and when ask^{d} if you had come to any resolution you answer^{d} me S^{r} you must attack you must attack." Armstrong's defence was "I don't remember I ever made use of such an expression, but thought an attempt of that kind more advisable than to take up so much time as would require to raise a battery and, Sir, you must excuse me to defend myself I observe that this is to be made a handle of ag^{t} me and the whole blame of that miscarriage thrown upon me . . ." Incidentally, the "only competent engineer" mentioned by Mr. Fortescue as having died at Boca Chica seems to have been a Mr. More. Wentworth's fine army, sadly reduced by wounds and disease, now returned to Jamaica, but on July 19th the remnants again landed in Cuba, this time at Walthanham Bay, near Guantanomo, under the mistaken impression that it was a convenient spot from which to attack Santiago, which was nearly 100 miles distant! We have the voluminous orders, with notes, of this futile expedition. Nothing was done, it is a sad tale of inaction and sickness, and the whole force was back in Jamaica by the end of the year, each commander laying the blame on the other, but Cuninghame loyally supporting his General.

Early in 1742 yet a third expedition sailed, now for Portobello Bay in the isthmus of Panama, with the intention of crossing the isthmus and attacking the rich town of Panama. But again nothing was done, and the incident is only casually mentioned in this correspondence. It should be mentioned that, although a junior officer, Cuninghame corresponded regularly with the Master-General of the Ordnance, and drafts of many of the letters are included in the collection.

Shortly before this a proposal of the Governor of Jamaica had been under discussion to send a small party to found a colony on the island of Ratan or Ruatan, in the Bay of Honduras, for which Cuninghame had volunteered his services. In July, 1742, he was not nearly so keen, but Wentworth insisted that he should go, and, to add to his annoyance, Armstrong was sent to lay out the town and plan of defence, and to leave orders for Cuninghame to carry out. Cuning-

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hame had a friend at Jamaica, Major James Forrester by name, with whom from Ratan he corresponded in French, no doubt for the sake of privacy. There is a priceless passage in one of these letters which deserves to be quoted :—" D'ailleurs Mr. Armstrone donne assez des amusemens qui reveille quelque fois ma fiel mais je le traite comme vous avez fait au feu Madame votre espouse pour le faire crever de rage." Cuninghame languished in this delectable island for two years, but resisted all temptations to settle there, although he received a grant of 200 acres of land from the Governor, Major Jno. Caulfield. He came home in 1744, and in March was appointed a Volunteer Engineer in Ordinary with the Army in Flanders, " assisting General St. Clair as Qrmr. Gen., and had the honour to be employed by His Royal Highness " (the young Duke of Cumberland) " on the entrenchments and most of the works going forward during the Campaign." The Connolly records tell us that he was present with St. Clair's regiment at the sanguinary battle of Fontenoy, on 30th April, 1745, and at the unfortunate action at Melle on 28th June, after which he witnessed the loss of Ghent on the 30th. He was sent home with Sir John Ligonier and joined Marshal Wade's Army for service in Scotland, and was seriously wounded at the battle of Falkirk, on 17th January, 1746. Mr. Connolly also mentions that he took part in St. Clair's abortive expedition to L'Orient in October, but I am inclined to believe, from the following incident, that he was not there but in Flanders, and was present at the battle of Roucoux which was fought on the 10th of that month. The incident which, he says, " fell under my own knowledge," is worthy of quotation : " After the Battle of Rocoux an officer of the Scots Dutch who had been wounded and Strip^{d} and Thrown indiscriminately with Sojers in the Same Condition into a Waggon driving to the Hospital ; A French Officer Seemingly of an inferior rank Stop^{d} the Waggon and asked the Scots Officer how he came to be Stripped, Regreated his Misfortune and alighting put his hand in the Officer's breach pocket remarking the Breaches were of English Shagg. The Prisoner imagined he was to be further Stripped excused himself from not being able to move because of his wounds, the French Officer beg^{d} his Pardon and said he meant nothing such, and went of. When the Scots Officer arrived at Leign and put his hand in his Pocket he found a purse of Gold The French man had Sliped into it."

Although serving as Deputy Qrmr.-General he had as yet no regular appointment in the Army, but shortly after this we find him addressed as " Captain William Cuninghame, One of His Majesty's Engineers," with the pay of £45 12s. 6d. a quarter, regularly forwarded to him in Edinburgh by Mr. Boddington of the Board of Ordnance, who deducted £4 11s. as " Agency on £182 " for the year, " Errors Excepted."

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There is nothing to show how long he was employed in Scotland, but in 1751 he was ordered to Minorca, in the rank of "Engineer in Ordinary," with Thomas Armstrong, probably his old friend, as "Director." We need not linger over this part of his career, which is fully described in the Corps History, how, on Armstrong's departure he was recommended for the post of Director, but failed to get the appointment, and when Bastide arrived to supersede him, obtained leave and started for home in disgust, with his wife and children. At Nice he gained certain information of the projected attack on Minorca and after spending all his savings, £1,600, on timber and other necessary engineer stores for use in the defence, he returned to the island, served throughout the siege as a Volunteer, and gained especial distinction in opposing the final assault on the Queen's Redoubt, in which he was again severely wounded. His passport "to go wherever his affairs required" was granted as a special clause in the Articles of Surrender, and as a reward he received from the King a Company in the 3rd Regiment of Guards, which carried with it the rank of Lieutenant-Colonel. There are no documents in the collection which belong to this period of his career, but in a diary of June, 1758, he notes that he saw Admiral Sanders sail into Portsmouth with two French prizes, the *Foudroyant* and the *Orphée*. "The *Foudroyant* is one of the Largest Ships ever built in France" and was "Admiral Galissonière's ship in which he engaged Admiral Byng, whose captain (at that time Gardner) had now the good fortune to take her in the *Monmouth*, a 64-gun ship, and Bravely fell in the Action." "Nothing can be oversaid in Praise of the *Monmouth's* behaviour, who had all the Merit of Compleat Victory. Had the *Foudroyant* and her Squadron met with so warm a reception off Minorca It is highly probable our Fleet would have rode triumphant, The transports of The French Army would have been destroyed And the garrison held out, as was afterwards demonstrable, From its not capitulating till 5 Weeks and 2 Days after this Engagement, without any re-inforcement. If any had got there what wou'd have been the consequence to Marshal Richelieu and his whole Army, Unsupported by a fleet, without transports, without ammunition, A scarcity of Provisions, and our Fleet riding Triumphant in the Harbour of Mahon. These things were so. The Consequences I humbly think undeniable, Sorrowful indeed are such reflections to any one who was employed in these Transactions."

In 1758 he received from Field-Marshal Ligonier, now Master-General of the Ordnance, the appointment of Chief Engineer to the Conjoint Expedition, under Commodore Howe and The Duke of Marlborough, then preparing for service against the coasts of France. The Instructions which he received on this occasion are among the documents and deserve to be quoted in full.

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SEAL.

Instructions for Lieutenant-Colonel William Cuninghame, Chief Engineer.

You are Carefully and Diligently in every respect to perform the Duty of Chief Engineer upon the present Service and Strictly to observe what is prescribed by His Majesty's Instructions, a copy of which, so far as it relates to the Duty of a Chief Engineer in Time of Action, is hereunto annexed, and we require you to see that the several Engineers do their Duty strictly conformable to their Instructions.

You are to make fair and exact Draughts of all Harbours and their Soundings, and Accurate Surveys of all Countries and Places you come to, of Attacks, Trenches, Intrenchments, Batteries, Incampments, or anything else wherein you may be employed or concerned.

You are to Muster the Engineers, and order the Paymaster to Pay them from time to time and in case any of them should die or be killed on this Service, you are to order the next in Rank to do duty in his Stead for which end you will receive herewith a List of the Engineers with the Dates of their Commissions, and you are to secure the Effects and Equipage of those so Dying or Killed and to cause an Inventory to be taken of the same as soon as possible in presence of an Engineer and the Commissary or Clerk of the Stores, so that his or their Lawful Representatives may be satisfied of your impartiality therein, and to send us a Duplicate thereof by the first opportunity.

You are from time to time to order the Commissary or Clerk of the Stores to Deliver such Instruments and Stores as are applicable to your Branch and he has orders not to Issue any Tents or other Particulars appropriated for the Engineers without directions in writing from you or the Commanding Engineer for the time being.

You are to transmit to us by every opportunity an Account of any Alterations that may happen among the Engineers, of their Conduct and behaviour and of every thing relating to the said Engineers so far as shall come to your knowledge.

Lastly—you are to follow all such Orders and Directions as shall be given you by the Master General, Lieutenant General and Principal Officers of the Ordnance for the time being, and to pay due obedience to the Commander in Chief of the Expedition or any other your Superior Officer according to the Rules and Discipline of War.

Given at the office of His Majesty's Ordnance under our Hands and Seal of the said Office this Fifth day of May, 1758, in the Thirty-First year of His Majesty's Reign.

Signed GEO. SACKVILLE; W. N. EARLE; A. WILKINSON.

CHARLES R. INSTRUCTIONS FOR OUR PRINCIPAL ENGINEER.

ARTICLE 7. In Time of Action or when there is intention of Forming or laying a Siege against any place he is to have a Draught or Ground Plot of the Place if possible if not to take a careful view of its situation as near as he can and thereof to make a Draught and to see where the Attaque or Attaques are most Advantageously to be made, how the Circumvallation and Contravallation (if need be) is to be laid out and designed and to direct and see the breaking of the Ground, planting

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of Batteries, making of Platforms conducting of Trenches and Mines and to leave such Engineer and Conductors as will be necessary to see them carried on and Executed and to be constantly moving from one attaque to another to see that all possible Expedition be made and so to divide the Engineers under him that they may relieve one another and never to suffer (as far as his Authority Extends) any Single Person to be wholly entrusted with a work or an Attaque without he will be assured of his Ability and Capacity to undertake and discharge such a Service.

Countersigned L. JENKINS.

The above Instruction Explains Perfectly the Duty of every Engineer that happens to be the Eldest upon any Service Particularly at Sieges, and there is no occasion for any other Instruction.

Signed J. L. LIGONIER.

List of Engineers for the Isle of Wight with the Dates of their Commissions.

Chief Lt.-Col. Willm. Cuninghame	– Sub Directr.	4th Jany. 1758.
Captain George Morrison	– In Ordiny.	4th Jany. 1758.
Ensign Charles Tarrant	– Practr.	14th May 1757.

We have the full "Journal with Remarks on the Expeditions to France in 1758," and also the "Book of Orders," handsomely bound in calf, with the royal arms printed on it in gold. These orders include very many points of interest, with which it is hoped to deal separately on a future occasion. The Expeditions have been described by many authors, including even Thackeray in "The Virginians." The first, when they landed at Cancale Bay, near St. Malo, and the second, under Gen. Bligh, when they destroyed the unfinished docks and defences of Cherbourg, were considered to be successful, but the last, again directed against St. Malo, when they landed in the bay of St. Lunaire and had to embark, fighting, with the loss of about 700 men, in the bay of St. Cast, a dismal failure. Colonel Cuninghame thought, and wrote, very seriously on the licentiousness of the troops on these and on the American expeditions of that year and recommended that the strongest action, even to the execution of senior officers, should be taken to put a stop to it. But he gives the following anecdote as a brilliant exception: "Reconoitring one day during our Late adventure to the Coast of France I was invited to dine at a gentleman's house on the Bassin of St. Maloes. A Lady at Table drunk Captain Cope's health, a Capt. in our Army in Lord Charles Hays Regimt; I enquired how he came to have the Honour of being known to her, She said his Actions entitled him to the Knowledge and Esteem of Every Person That the first time we were at St. Maloes this Gentleman Commanded a Party near St. Servan at a Gentleman's Seat Abandoned by its Master and Stript

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of his furniture; that Capt. Cope had found a Concealment of 20000 Livres worth of Plate which he buried in the Garden and wrote to the owner at St. Maloes who entertained The Highest sense of Gratitude and Esteem For So Generous Proceeding."

He contrasts the harbours on the Coast of France, "better Fortifyed than any in Europe," with the unprotected smaller harbours of England, but considers that "The French could make no Considerable impression, Except by exciting rebellion, or in the Channel, Unless they have Superiority at Sea, which is the great National object to Prevent." Still he recommends that these smaller harbours should be fortified, as at present many are liable "to have Ships cut out by Every Cruizing Privateer, who may even set the open defenceless Towns on fire."

The troops were back at Portsmouth by the third week in September, and on the 12th November Cuninghame sailed on his last campaign, the Conjunct Expedition against the French Caribee Islands, under Commodore Moore and General Hobson. "The Muster Roll of the Brigade of Engineers for December, 1758, at Sea" gives the names of the following officers:—

Chief Engineer Lieut. Col.	Willm. Cuninghame.
Sub. Engr.	Thos. Wilkinson.
Practitioner Engrs.	Richd. Muller.
	Theo. Lefanu.
	Archd. Campbell.
	Robt. Morse.
	Patk. Ross.

and he was joined later by Captain Lieut. Alex. Kennedy, Lieut. Orasgol, and Practitioner Engineer Shaund.

Lieut.-Colonel Cuninghame's two last letters to the Board of Ordnance are included in the collection and, as they give a full account of the action of the expedition, will be given in full:— The first is dated January 29th, 1759.

RIGHT HONBLE. AND HONBLE. GENTLEMEN,

The Fleet arrived at Barbados Jany. 3rd several of the Ships were amissing which dropt in Day after During our stay in Carlisle Bay and all arrived before we sailed from thence except ye Hospital Ship and a few others of small Consideration. I applied to the Commander in Chief for somethings necessary for carrying on a Siege particularly 6000 Pickets which were paid by his order and stated to the Contingent Accompt. We sailed from Barbados Jany. 13th and arrived before Port Royal in Martinico Jany. 15th. The Harbour Coast and Batteries were reconoitred the 15th and 16th and Report given in to the Commander in Chief of the strength of these Batteries, their Entrenchments, state of the Beach, etc., as more fully specified in the Report given in by the Chief Engineer. In the morning of Jany. the 16th the Men of

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War silenced a Battery upon Negro Point and one upon the left of the Entrenchment at Cas na vire and Scoured the said Entrenchment which appeared to be defended by 800 or 1000 men. The Army disembarked about 2 or 3 miles nearer Port Royal without opposition and took the strongest post near to Nigro Point which was the readiest Communication with the Fleet. Next Morning a Plan was given in for the fortifying of the Camp and beginning the Approaches to Port Royal, but a Resolution being taken to reimbark that Evening and the Troops retreating, three slight Redoubts were hurried up on the Right Left and Centre of the Ground which the Troops occupied, these were finished before Night. The Troops reimbarked without any molestation and were off the Town of St. Piers next morning. The Town, Forts, Entrenchment and landing Places were reconoitred and Report made by the Quarter Master Genl. and Chief Engineer to the Commander in Chief and Commodore, next morning being the 20th Jany. the QrMr. Genl. and Chief Engr. were ordered to go on in the Winchester Man of War to reconoitre Basseteire in the Island of Guada Lupa. Sketches were made of the Bay, Batteries, Number of Guns, Entrenchments and proper landing Places and an Opinion given in to the Genl. and Commodore of what was thought most expedient to be done in the Attack of the Fortifications of Basseterre, as per Report. The 22nd The whole Fleet plied off the Bay of Basseterre, next Morning the Ships went in and attacked the Fort and Batteries, as expressed in the Plan, by night these Batteries were silenced. The Bombs were ordered in to play upon the Fort and did some execution, they threw Carcasses into the Town, which was set on fire, burnt a great part of the Night in several Places and all next Day, which consumed most part of the Town. The Fleet came all to an anchor the 24th Janry. and the Signal was made for the Debarkation which was immediately accomplished without any loss. The Town, Entrenchments and Fort (also named Fort Royal) were abandoned and the Troops took possession of the most advantageous Ground in the Circuit of the Town. These Posts are a fortifying and the Enemy who have retired two or three mile into the Country on heights and in woods seem to be doing the same thing. A little skirmishing dayly passes. Numbers of Negro's come in, but not so many as was expected. Some Conferences have passed between our Commanders and the Governor the issue of which is not publickly known. The fortifications of Fort Royal are repairing with all the Expedition our Time or Power will allow.

Right Honble. and Honble. Gentlemen,
Your most obedient
Humble Servant.

The second letter is dated 5th March :—

My last to the Board was dated—Janry., a Copy of which is sent with the present Occasion, since that Time the Army has remained in its then Position, frequent Skirmishes have happened betwixt our out Posts and the Enemy which have been attended with the loss of some Officers and a considerable number of wounded men. The Enemy

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continue entrenched as at the beginning and by a Deserter we hear they receive Supplys from Martinico of Provisions and Ammunition. It being determined to Garrison Fort Royal and to strengthen it as much as the Time of the Army's staying here would admit of I have escarped a great Part of the Foundation of the Ramparts where they were thought Accessible. Filled the Ditch with Trous des loups to make it more impassible for an Escalade. A safe Communication is made to the Sea under the Cannon of the Fort, and otherwise defended above Surprize. A Place of Arms is made for Part of the Garrison to encamp in. A Covered Way is formed and palisaded. Some Buttresses are made to strengthen the Rampart, and built up where Damaged. All the Buildings in the Fort are pretty nigh repaired of the Damage done by the Shot and Shells. New Shades for Barracks are building and new Casmates are a making in the Body of the Rampart. All these particulars are more fully set forth in the Report of the State of the Garrison to the Commander in Chief A copy of which I have transmitted to the Honble. Board with a Plan distinguishing the Additions made to the Fort. I have likewise transmitted a Copy of my Thoughts on the Defence of the Place left with Lieut. Col. Debrisay now appointed Governour of Fort Royal. Lieut. Wilkinson sub Engineer and Mr. Muller Practitioner on hearing of a Garrison ordered to be left applied to me to be appointed for that Service as by their Letters Copys of which are inclosed and I recommended them accordingly to the Commander in Chief. Fort Lewis was taken 1 Febry. by a Detachment of Men of War from the Fleet. The Entrenchments were attacked and taken by the Highlanders and Marines under the Command of Lieut. Col. Prycant. It is a Star Fort and by the Report of Engineer Orasgol is in a better state of Defence as to its Ramparts than this Place. There are two detached Redoubts commanding the Entrenchments which are very Extensive. The Harbour is the best and safest in the West Indies. I have not been allowed to go from this or make any Survey of it but shall as soon as my Duty here can be dispensed with. All the Engineers are in perfect good Health not withstanding their having been more on Duty than any other Corps of Officers in the Army which are now very sickly. The Officers of the Line who were ordered to do Engineer Duty are now rendered to their Regts. because of their want of Officers and I have ordered their payment so far as they were employed. Genl. Hopson died on the 27th Febry. and is succeeded in the Command by Major Genl. Barrington. I am with all due Respect, etc."

He paid his intended visit to "Fort Louis on Grande Terre," and his report upon its "Tenableness," dated 21st March, 1759, is the last paper of the series. The Corps History states that he died in Quadalupe shortly afterwards.

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PROFESSIONAL NOTES.

"CIMENT FONDU."

WITH reference to the article on *Ciment Fondu* by Capt. J. C. P. Tosh, M.C., R.E., which appeared in the September issue of this Journal, the following extract from the *Concrete and Constructional Engineering* for August, 1923, gives an opinion of the engineering profession on the utility of the material.

"Mr. Butler's paper*, referred to above, also referred to a new aluminous cement which possesses the property of rapid hardening, the strength at an age of one or two days being equal to that of Portland cement at twenty-eight days. This cement is composed essentially of aluminate of lime, and in this aspect differs from Portland cement, which is composed for the most part of silicate of lime with only a small proportion of aluminate of lime. The property of hardening rapidly is one of considerable value in certain directions, notably in road repair work, where it is possible to limit the exclusion from traffic to forty-eight hours. For other emergency work this cement will also have advantages, and among other claims it is asserted that piles can be driven three days after moulding.

"Concrete users have become so accustomed to waiting for periods of days or even weeks before concrete is sufficiently hard to carry its own unsupported weight or to bear superimposed loads, that it is difficult to envisage the saving in time and economy in procedure that may result if concrete attains in twenty-four hours the hardness usually developed in a month. Subject to certain considerations, it is possible to foresee remarkable developments in connection with aluminous cements. These considerations are endurance and cost.

"There has been no published evidence that aluminous cement maintains its high strength and does not deteriorate with time. Concrete blocks made with this cement a dozen years ago and immersed in sea water and water impregnated with sulphate are reported to be intact, but apparently the maximum period at which tensile or compression tests have been made is three years, although again it is reported that there is no evidence of retrogression during this period. There is no reason on chemical grounds, to suspect deterioration, but it is obvious, that engineers must proceed with caution, and the new cement will have to stand the test of time before it is regarded unreservedly as a substitute for Portland cement.

"The second consideration is that of cost. Aluminous cements require

* "British Standard Specification for Portland Cement."

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as one of the raw materials an aluminous mineral such as bauxite or corundum, and neither of these is known to exist in England. Hence at the present time aluminous cement is made only in France and Switzerland, and the price in England is double that of Portland cement. Even if manufacture is commenced in England the aluminous raw material will need to be imported, and this will form a substantial addition to the cost of manufacture, which will also have to carry the additional cost of grinding the very hard-fused material to the great fineness that is necessary. However, with an industry still in its infancy, there are doubtless possibilities of cheapening the manufacturing processes. The high price now current will, in fact, tend to restrict the use of the cement, and thus the caution which we have suggested is necessary will automatically result. But we do not lose sight of the possibility that in course of time aluminous cements may lead to marked changes in constructional methods, may extend the uses of concrete, and to a certain extent replace Portland cement; at the same time, rendering concrete of still greater importance in the engineering and constructional operations of the world."

The French company which manufactures *Ciment Fondu* have now opened an office in London under the name of the Lafarge Aluminous Cement Co., Ltd., Regent House, 89, Kingsway, London, W.C.2., and are willing to answer enquiries with reference to their products.

THE STREAM-LINE FILTER.

(Hele-Shaw System.)

A NEW and most interesting form of filter has recently been placed on the market known as the "Stream-Line Filter." The construction is simple and, from the records of the laboratory tests made, its efficiency is marvellous.

The essential portion of the Stream-Line Filter consists of a stack of sheets of waterproof paper pressed into contact with one another by suitable means. When so arranged, the numerous circular holes with which the sheets are perforated coincide and form passages or tunnels running from end to end of the stack. Of these tunnels about half the number communicate with the receiving end of the filter and the remainder with the delivery end. The liquid to be filtered is led under pressure to the receiving tunnels and escapes through the delivery tunnels after passing between the faces of the waterproof paper sheets.

The filtration is effected at the edges of the paper forming the sides of the receiving tunnels, only the liquid filtrate passing between the sheets of paper. The wear and tear of the paper is therefore practically *nil*, the grit never passing between the sheets. The sludge or residuum is all collected on the sides of the receiving tunnels.

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from whence it can be easily removed by various means when the filter requires cleaning.

The paper used is prepared by a patented process and is of a fibrous texture, with a dull surface. In appearance it is very similar to a common type of paper in daily use. Calendered paper with a glossy surface does not appear to effect filtration, the surface being too smooth.

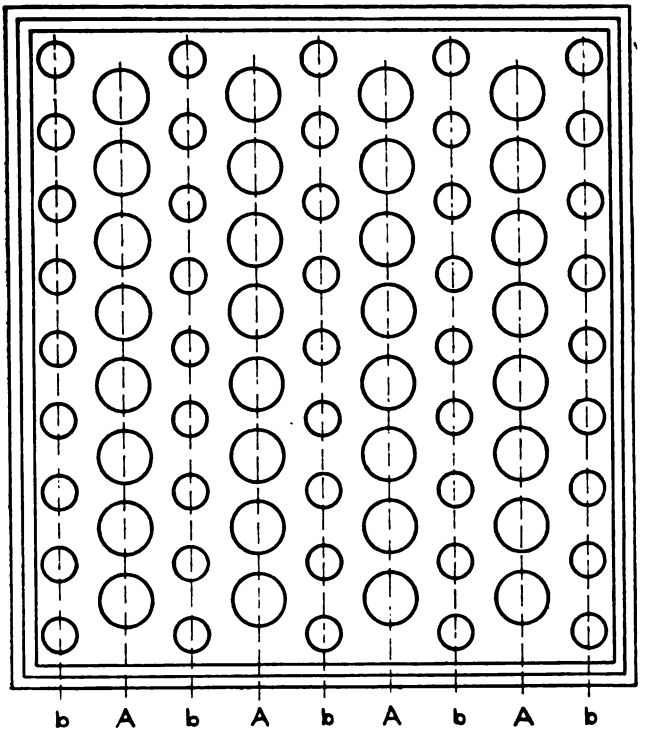

FIG. 1

Fig. 1 shows the arrangement of the holes in the filter paper, the line of flow of the filtrate is between the receiving tunnels A and the delivery tunnels b.

Fig. 2 shows the general arrangement of a filter capable of dealing with about 700 gallons of water an hour under a pressure of about 50 lbs. per sq. in. The height of this installation is about 4 ft. 3 in. and breadth about 2 ft.

A battery of 16 filters, capable of dealing with 10,000 gallons an hour, occupies a floor space of about 9 ft. by 4 ft. From this it will be seen that the apparatus is extraordinarily compact.

The degree of filtration effected can be regulated by the pressure of the packs of paper, and some of the results which have already

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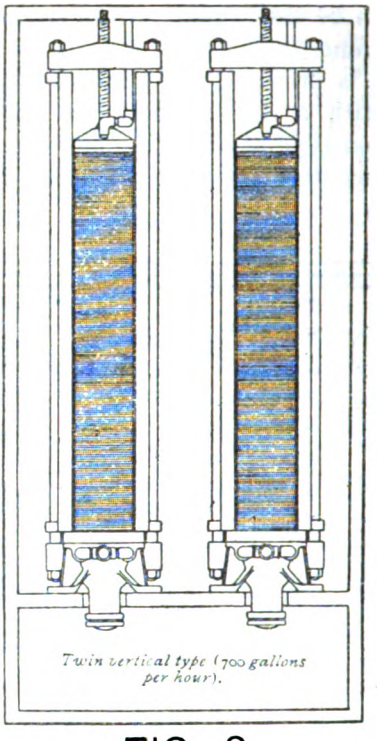

FIG. 2

been effected by fine filtration are extraordinary. Not only can grosser impurities, such as suspended matter, be abstracted from a liquid, but emulsions can be separated into their constituents, and even liquids coloured by some substance in solution can be filtered clear and colourless. Moorland water stained by peat which has hitherto resisted every attempt to remove its colour by filtration, can be delivered in a perfectly colourless condition. The powerful dye Erythosin, which has a brilliant orange colour with a florescent, green glint when diluted with 5,000,000 parts of water, is completely separated, leaving a colourless filtrate.

In order to understand why a small filter, as illustrated in *Fig.* 2, has such a large capacity, it will be necessary to arrive at an idea of the available filtration surface in the apparatus. Each pack of papers consists of approximately 8,500 sheets and each sheet is pierced with 32 receiving holes of approximately $1\frac{1}{2}$-in. circumference. The liquid is forced between each sheet round the circumference of every hole, and there are, therefore, $8{,}500 \times 2 \times 32 = 544{,}000$ units, each $1\frac{1}{2}$ in. long, contributing to the flow, or nearly 13 miles of filtration surface. A rate of flow of approximately one drop per minute per inch of filtration surface would produce the 700 gallons per hour.

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The sludge or residuum collects in the tunnels and can be very simply disposed of. If it is valueless and can be run to waste, the ends of the receiving tunnels can be opened by means of a stop-cock and flushed out by the unfiltered liquid under pressure, the whole operation taking only a few seconds. If, however, as is often the case, the residuum is a valuable by-product and it is desired to collect it the following method is used. In each of the receiving tunnels is a light, free-fitting, floating piston, which normally lies in a pocket in the end covers. When it becomes advisable, owing to a falling off in the flow, to remove the residuum from the filter, the liquid prefilt under pressure is admitted behind the piston which then traverses the length of the pack and drives before it the sludge, which is evacuated through ports in the end cover.

The commercial uses to which a filter of this description can be put are manifold. Many trade wastes which hitherto have been neglected, can now be worked profitably. Certain salts in solution have already been extracted and it is quite within the bounds of possibility that potable water will be manufactured from sea-water at a far less cost than by distillation. Milk can be filtered, the filtrate being a colourless liquid, while the residuum is white and solid.

Although research into this method of filtration is still in its infancy, from results already obtained it would appear that it is possible to discriminate between molecules of varying sizes. If a solution is made of two salts, say, copper sulphate and common salt, it is possible to extract all the copper sulphate in the filter, the filtrate being a solution of common salt. Little at present is known of the pressures required to abstract various substances, but it is reasonable to infer that, by having a succession of filters at varying pressures, an emulsion or a solution of several chemicals can be separated into their original constituents. If, as it appears, this filter can deal with masses of the nature of molecules there should be no difficulty in dealing with bacteria, and it may be possible to grade bacteria according to their sizes, thus opening out further fields of research.

D.K.E.

SURVEY NOTES.

LATE in September and early in October the Field Survey Platoon returned in two parties from Constantinople. Captain Hutchison, who was the Assistant Director of Surveys in that area, came home some months ago, but the Platoon, which has been engaged in the preparation and printing of maps, remained till the last, under Lieut. Godfrey-Fausset. Their labours in dealing with Turkish material have been very interesting. The Turkish geographical units were

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trained on French lines, and are producing good, reliable maps, both on the large scale of 1 : 25,000 and on the 1 : 200,000. Like most surveys, however, the Turkish requires knowing, and there is a strip in the Ismid Peninsula where triangulations from the Asiatic and the European sides are scarcely on bowing terms. The printing machinery was in the last stage of collapse and the demands upon it were often abnormal. As a body, the Platoon says that it is not sorry to come back to the more prosaic, but easier, routine of the Ordnance Survey.

Captain P. K. Boulnois and Captain James, Assistant Commissioners on the Darfur Boundary Commission, have also returned. Their surveys extend over a matter of 1,000 miles, and in an area which has cost the Soudan Survey a heavy price, for Colonel Pearson died from fever contracted during the field work, and Mr. Boyce, his successor as Surveyor-General, has had a very arduous and trying time. The French Commission also suffered by losing their Doctor, whose loss was as deeply felt by his British Colleagues as by his compatriots. Technically, the most interesting feature of the Commission was the determination of longitude from wireless time signals. No survey which is beyond the reach of existing triangulations can afford to neglect this method, but it is not easy to keep pace with the rapid advance of wireless reception and to standardize methods with any hope of even some permanency.

Captain Latham has just sent home the first sheet of the new topographical survey of Trinidad. It should be a most attractive series, for the country is delightful to look at on a map, although the difficulties of survey must have been great. Oddly enough, the scale chosen is 1 : 50,000. The popularity of this scale is marked. The new French " Carte de l'Etat Major " is a 1 : 50,000, and German, Austrian and Italian mapping is steadily inclining to the same policy. A large block of Central and Southern Spain is also mapped on this scale, as are Holland and parts of Switzerland and Sweden. The maps produced by the Field Survey Platoon of the Ismid and Chanak areas were also at this scale.

The national Surveys of Germany and Austria are interesting just now on other grounds. Like all other European surveys, they were, before the war, military or semi-military in character. Now they have been converted into civil departments for the reason that the military establishments allowed are too small to permit of any other solution. But the German survey has, none the less, decided on a programme which will vastly lighten the geographical work of home defence and are about to introduce a grid, similar to our present military grid, on all topographical maps. Their new cadastral scale is to be 1 : 5,000 (or 12 in. to 1 mile approximately).

Our European Boundary Commissioners, in so far as the delimitation of the frontiers affected by the Treaty of Versailles are

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concerned, are nearing the end of their labours. Lieut.-Colonel Giles in Albania is, no doubt, having the most thrilling time of all of them. His troubles, in ascending order of magnitude, may be described as technical, political, climatic and animal. When these commissions are past history and our representatives are free to describe their experiences, we should hear much of interest. Other commissions will, no doubt, form soon for the delimitation of Eastern frontiers. These will tend more to a geographical character than the present European commissions have done.

Everyone else has their staff rides and exercises, and Survey Units have followed the prevailing fashion. An exercise in which R.A. and R.E. surveyors co-operated was held in July last. It is natural that one of the most important points which emerged was the importance of immediate interchange of data. In France, during mobile operations, observers had to rely on the erection of noticeable beacons on prominent spots, on helio, or (in dull weather) on the Lucas lamp, to get into touch with each other. These alternatives were all very unpopular with troops in the vicinity. There seems room for a vertical rocket, or luminous and vertical projectile, as used by the Germans; but even so, either telephonic (preferably wireless) or personal touch between R.A. and R.E. surveyors is essential if the Artillery are to be properly served. The survey exercise was, this year, theoretical in character. It is hoped to conduct a similar exercise next year in a more practical fashion and to complete the full technical programme.

Some interesting exploratory surveys have been completed lately in Arabia. Major Holt, of the Iraq railways, read a paper before the Royal Geographical Society on the "North Arabian Desert and its Future" in February last. Sir Percy Cox very kindly consented to his working afterwards with the Geographical Section of the General Staff in plotting his route. Fortunately, his observations of latitude, longitude and height were admirable, and the result of his labours is to fill with reliable matter a little-known strip between Basra and Palestine. Captain Cheeseman has also given us most valuable information regarding the western shore of the Persian Gulf, where he has broken entirely fresh ground, and has extended the Gulf of Salwa no less than 40 odd miles to the south.

In China General Pereira's recent journeys are helping to pull the vague mapping of the central and south-western provinces into more definite shape. The Carnegie Institute have provided a badly-wanted skeleton by fixing the latitude and longitude of many Chinese towns, but valuable as such work is, it does not help the topography much without some form of connecting link. It is gratifying to note the fair agreement between General Pereira's route sketches and those of Major Davies (now General Sir Francis J. Davies, K.C.B., etc.). There is, however, still far too much play

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for the imagination in mapping Asia, and unfortunately the vagueness understandable in, shall we say Borneo, is found even in old-established British Colonies.

The R.E. staff at Hong Kong have, very wisely, given up waiting for the systematic survey of the leased territory by special civilian or military bodies, and have started to extend the 8 in. to 1 mile map which covers part of the area by an excellent 1 : 20,000 plane table survey. The first field work, done by Lieut. Taylor, R.E., has recently arrived and seems of a high order. It is a pity that more accurate mapping is not done by the many officers who are capable of it. Reconnaissance is a name which covers a multitude of omissions. It is not of much value to read of an admirable water supply if there is but a remote chance of ever finding it.

The *Text-book of Topographical Survey* is to be revised again, and, fortunately, Sir Charles Close has consented to re-edit it. There is no other book on survey so remarkable for the effective way in which it covers the necessary range and avoids the fads of the enthusiast.

The Colonial Survey Section has been formed again and has embarked for the East with Captain Kirby in command and Lieut. Willis as his subaltern. The remainder of the section, five in number, are topographers and observers from the Survey Companies, including C.S.-M. A. C. Wilde, D.C.M., R.E., who is a host in himself. The Colonial Survey Section has a very fine record behind it and, composed as it now is, can hardly help adding to its laurels.

Those of us who are members of the Royal Geographical Society, and have got to know something of Mr. Reeve's untiring efforts and inventive mind, congratulate him heartily on the award of the "Cullum" Gold Medal of the American Geographical Society for 1922.

W.

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MEMOIR.

COLONEL WILLIAM FITZHENRY SPAIGHT.

On May 19th of this year there passed away one of the older generation of Sappers in the person of Colonel W. F. Spaight, in his 81st year.

Colonel Spaight gained his first commission in the Royal Engineers in 1863, and joined at Addiscombe. He later served at Aldershot (where he was Adjutant of the R.E. Companies), Malta, Ireland (where he spent some time on the Ordnance Survey), Egypt, and Jamaica. He served in the Egyptian Campaign of 1884–85, for his services in which he was mentioned in dispatches and gained a Brevet Lieutenant-Colonelcy, being later appointed Brevet Colonel. He served as C.R.E. in Jamaica, and for the last five years of his service was C.R.E. in Cork. He retired in 1895 with the rank of Colonel.

An Irishman, Colonel Spaight came of a line of soldiers. On his retirement he settled down at Union Hall, County Cork, devoting his time there, and at his old home in Clare, to his tenantry and estate. A J.P. for the County, he occupied himself with the social and economic questions of the day, but he avoided politics. His endeavour always was to promote fellowship and good feeling between all members of the community, especially between landlord and tenant. His interests kept him in touch with a wide circle, and he never lost connection with his old Corps. His keen insight into character and his innate sense of justice brought him grateful recognition by many in widely different classes as friend and counsellor.

During the Great War his age and health prevented him from offering himself for active service, but he did good work in helping, to the best of his ability, pensioners and dependents of those in the Services.

The last two years of his life were spent in enforced exile from his old home, when, in common with many of his neighbours, his home was burned to the ground—a reprisal, it was stated, for counter-destruction by the "Black and Tans." He never fully recovered the blow, but bore no personal grudge against the perpetrators, realizing that he was but one victim in the general upheaval, which was directed not against individuals but against a class and country.

His death is regretted by a wide circle.

T.

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BOOKS.

GERMAN STRATEGY IN THE GREAT WAR.

By BREVET LIEUT.-COLONEL PHILIP NEAME, V.C., D.S.O., *p.s.c.*, R.E. (Edward Arnold. 10s. 6d.)

FOLLOWING the excellent example of Major-General Sir G. Bowman-Manifold, Colonel Neame has published some of the lectures which he gave when on the Directoring Staff of the Staff College. It is to be hoped that other instructors will be emboldened by the lead given by these two Engineer officers. It is hardly within the memory of any serving officer that the instruction provided at Camberley has thus been made available for all. The book is no dry strategical treatise, but an epitome of the whole war on the continent, apart from its trench-warfare features. It is enlivened by remarks on the personalities of the leaders and significant asides. To those who have only studied the Western Front it will be of special value, as it gives a very clear summary, with plenty of maps—there are seventeen in the volume—of the campaigns on the Russian Front. How many of us could say what happened in the Russian offensive near Lake Narotch in March, 1916, which the author suggests was undertaken in unsuitable weather for the chivalrous purpose of trying to help the French, then engaged in a death-struggle at Verdun ?

The chapter headings give a good idea of the contents. They are: The German Strategic Plan, The Frontier Battles of the Western Front, The Change in the German Plan of Campaign, The Battle of the Marne and Events in the West to the end of 1914, Russian Plan of Campaign, Battles of Tannenberg and the Masurian Lakes, First and Second Invasions of Poland, " 1915," " 1916," The Rumanian Campaign, " 1917," Preparations for the Offensive in 1918, The Five German Offensives in 1918, and Ludendorff, his Career and Character. As regards Ludendorff, it might be pointed out that he, like Col. Neame, was an instructor at his Staff College.

Some pretty problems are suggested. What, for instance, would have been the effect of a German withdrawal in June, 1916, before the battle of the Somme, like the one Ludendorff had already carried out in Poland in the autumn of 1914, and was to repeat in 1917 ?

It is to be regretted there is no chapter on the influence of fortresses. Colonel Neame does not think that the defence of Liége delayed the Germans ; he barely mentions Maubeuge ; and does not draw attention to the value of Lötzen and the fortifications among the Masurian Lakes in holding back Rennenkampf in the Tannenberg Campaign. Nor, though he mentions the facts, does he deduce any conclusion from the

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effective support given to the Germans by the Nied fortified position, and to the French by the Grand Couronné. He admits that "the French Eastern fortifications still precluded any hope of a rapid advance or victory on the common Franco-German frontier." It is to be hoped that the General Staff of to-day is not being trained to despise technical assistance as its predecessors of 1914 were.

Otherwise Col. Neame seems to have taken up every point of importance in regard to the German strategy, even to the operations of the Railway Troops, and the influence on the Supreme Command of the Royal Princes commanding armies. In his estimate of Ludendorff he might have laid stress on the extraordinary care exercised by the First Quartermaster-General in the selection of his subordinates, and the way in which he made Hoffmann, Wetzell, Bauer, Bruchmüller and others do the detail work, whilst he made the great decisions and found the will-power. Like Moltke in 1870, he was extremely well served, and deserved to be.

As the book will certainly be widely read for examination purposes, it must be pointed out that there seem to be two slips in it. The first is that, in comparing Schlieffen's plan of 1905 with Moltke's deployment in 1914, Colonel Neame tells us that in 1905, 78 divisions (including 16 Ersatz divisions) were allotted to the offensive wing north of Metz–Thionville, and 9 divisions to Alsace-Lorraine. He does not say this was for a one-front war and does not deduct the 10 divisions which Schlieffen thought necessary to operate against Russia. In 1914 he says Moltke sent 12½ to Russia (only 9 active and reserve divisions really), 61 divisions to the offensive wing, 27 south of Metz (the German accounts say 16 active and reserve; to make up 27, the garrison divisions of Metz and Strasburg, not counted in 1905, and 6 Ersatz divisions must be included). Thus the comparison made in the book is not a true one. It is further vitiated by the fact that the Ersatz divisions were not field troops, but, in 1914, bodies of untrained men without transport, and fit at best only to hold defences. For the purpose of comparison it would seem that the figures for active and reserve divisions, were in 1905: Russia 10, offensive wing 53, defensive wing 9; and, in 1914: 9, 54 and 16. Of the 4 Ersatz divisions, Marine divisions and Landwehr troops sent to Antwerp no account whatever is taken. That the war was lost by Moltke "watering down" Schlieffen's receipt for victory is one of the favourite pleas of the German General Staff; it seems strange to find a British General Staff Officer appearing to agree. It was the Allies who spoilt the scheme; and it was, after all, a mere Staff College plan evolved without sufficient account being taken of the action of the enemy, casualties or the influence of fortresses. It might have worked out at a war game at manœuvres, but was bound to fail in war. Even though the French committed many serious mistakes on which the Germans cannot have calculated, it failed. Possibly, had Great Britain landed her 13 Mounted Brigades at Ostend on 27th August, instead of one brigade of R.M.L.I., it would have collapsed in the 39 days that Schlieffen calculated he required to settle the French.

J.E.E.

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THE OFFICIAL HISTORY OF AUSTRALIA IN THE WAR OF 1914–1918.

Vol. VII. SINAI AND PALESTINE. By H. S. GULLETT. (Sydney: Angus & Robertson. London: The British Australasian Book-Store, 51, High Holborn. 28s.)

THIS is the second of the volumes of the Australian Official History to be published. The first dealt with Gallipoli. The present one, though it refers generally to the operations in Sinai and Palestine, is concerned almost entirely with the work of the Australian Light Horse.

The author accompanied this force as official correspondent for the special purpose of collecting material for a history. He has written, not a military record, but a popular account. This, though it may enthral the relatives of those who fought, is of small value to a student of war. The Palestine campaign was described in the British Official Record, *A Brief Record of the Advance of the Egyptian Expeditionary Force*, as a "medical and engineer war"; the official German account of Falkenhayn's command, issued under the name of "Yilderim" by the *Reichsarchiv*, quoting a phrase of Lord Wolseley, called it, in entire accordance with the British view, an "engineer and doctor's war." Mr. Gullett has tried to convert it into a cavalry war, or, to use his words, a "mounted infantry" war; for he says:

> "The light horse was not a cavalry force. Its members were not armed with sword or lance. They were mounted riflemen, or, in other words, mounted infantry."

The book is full of personalities and petty skirmishes.
Thus we find the following appreciation of a certain general:

> "Standing well over six feet, handsome and well proportioned, General —— (the name is really given in full !), looks what he is, a very spirited cavalryman. He is, by intuition, a master of cavalry rather than a leader of mounted riflemen. . . . 'Fighting Charlie,' as he was known after South Africa, had never been a deep student of war. He relied on his native wit and his common sense rather than upon the text-books."

Of General Sir Archibald Murray the author writes:

> "Murray possessed some great qualities as a soldier and many charming qualities as a man. But he was the wrong man for Egypt."

There are 844 pages in the volume; but there are little more than a dozen references each to the engineer and medical services. As there is no order of battle, there is no clue to the staff and units employed. The only engineer unit of which we can find mention is the 1st Field Squadron Australian Engineers, at the passage of a river. Elsewhere the "Engineering Field Squadrons" and a Field Troop of the Camel Brigade are alluded to, and Brigadier-General R. E. M. Russell, R.E., is spoken of three times as commanding the Engineers. There are casual mentions of the Engineers being engaged on water supply,

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repairing a bridge near Damascus and taking part in the demolition of a railway.

The Medical Service hardly gets as much mention, though it is given general praise, and it is said:

> "In no branch of the Army was the fight waged with more zeal and effect and with more influence on the success of the campaign";

but its organization is not given, and, beyond the construction of incinerators to burn refuse, and the initiation of "extraordinary devices" to prevent the breeding of flies—which are not further described—there is little notice of the medical work.

Mr. Gullett takes a new view of General Murray's battles of Gaza. He thinks that there was no necessity for the withdrawal at dark in the first, and suggests that

> "the leader or leaders responsible for the orders were too far from the ground of operations."

The second failure is attributed to a certain general's

> "boundless confidence that he could crush the Turks at any time and on any ground he chose."

There is a tendency throughout the book to praise Germany's political and military sagacity and German organization and to depreciate and even ridicule British methods.

The book is illustrated with 83 photographs of persons and scenery and has 77 maps.

J.E.E.

THE AUSTRALIAN FLYING CORPS.

Vol. VIII of the Official History of Australia in the War, 1914–1918, by F. M. CUTLACK. Price 25s.

AUSTRALIA succeeded in raising and maintaining four air squadrons during the war. No. 1 served in Egypt and Palestine, while Nos. 2, 3 and 4 reinforced the British squadrons on the Western Front. The doings of these four squadrons are remarkably well told by Mr. F. M. Cutlack in Vol. VIII of the official history of Australia in the war. The book automatically divides itself into two parts. The opening phase of the campaign in Mesopotamia, ending with the investment of Kut, and the operations in Egypt and Palestine are dealt with in the first part, while the second deals wholly with the war on the Western Front. In all these theatres of war Australian airmen bore their part.

The campaign in Palestine is unique in that the air force played a preponderating rôle. This is no place for debate on the merits of an air force, but no one with an open mind can afford to ignore the lessons of the air campaign in Palestine. The victory was overwhelming and complete. A retreat was converted into the most disorganized rout in the history of modern warfare—and this was largely accomplished through the agency of the air service. Mr. Cutlack's first twelve chapters, which culminate with the battle of Armageddon should be

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closely studied by all students of Imperial Defence. Not only are these chapters the chronicles of No. 1 Squadron, Australian Flying Corps, but they excite admiration and wonder. By stating the facts of the most significant air campaign of the war they give food for thought.

The Australian flying squadrons were conspicuous for the thoroughness with which they did their work, and in air-fighting they were pre-eminent. Even while they were making history in the air their records were most carefully compiled on the ground. Would that other units had conformed more religiously to *Field Service Regulations* in the matter of war diaries. How much easier would be the task of the unfortunate historian.

Mr. Cutlack has not allowed himself to be fettered by red tape or official jargon. He has given us something of the nature of an intimate unit history, in which he has taken care to stick strictly to facts. The book is well compiled and explanatory matter, which might interrupt the narrative, is dealt with in Appendices and Footnotes. It is unfortunate that Mr. Cutlack did not have at his disposal Volume I of the official history of the war in the air by Sir Walter Raleigh. This would have prevented many errors, chiefly in the Introduction and Appendices. For example, he tells us on page xxii of the Introduction, that of the four squadrons of the Royal Flying Corps which accompanied the original Expeditionary Force to France, " Two were equipped with homogeneous flights of B.E.2's, Henri Farmans and Maurice Farmans." Actually of these squadrons No. 3 made use of Blériots and Henri Farmans and No. 5 of Henri Farmans, Avros and B.E.8's. On page xxiii he gives the S.E.4 as a type of machine which replaced the Farmans. No S.E.4 was ever used overseas. Again on page xxiv he credits the D.H.2 with the destruction of Immelmann. Actually, McCubbin accomplished this in a F.E.2b. There are a few others, but these, however, in no way affect the value of this book, which undoubtedly will be read widely and with great interest.

J. MORRIS, *Captain*,
Air Historical Branch.

PHOTOGRAPHY AND ITS APPLICATIONS.

THE intellectual development of man has been chiefly the result of his aptitude for devising tools and implements. As Mr. O. G. S. Crawford has said, in a recently published book: " Man was the first animal to grow a limb outside of himself by making tools out of wood and stone. . . . Each step in advance was a small one, hardly won, perhaps; but each step makes the next more easy." To this it may be added that it is impossible for the most far-seeing of men to say where the invention of a new " implement " may carry us, or what consequences may follow, scientific or practical.

No better illustration of this fact could be found than in the invention of photography. The first true photograph was taken by our fellow-countryman, Fox Talbot, in the year 1835, eighty-eight years ago; he had begun to experiment in the matter in 1833. The book under

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review* quotes Fox Talbot with reference to a photograph of Lacock Abbey, his country house; he says: "this building was the first that was ever known to have drawn its own picture. It was in the summer of 1835 that these curious self-representations were first obtained. Their size was very small; indeed, they were but miniatures, though very distinct: and the shortest time of making them was nine or ten minutes." In these early days of Fox Talbot and Daguerre it is natural that the only anticipated application of photography was pictorial. Paul Delaroche, the painter, is quoted as saying: "Painting is dead from to-day." Well, painting did not die, and is not likely to die, so long as there are people intelligent enough to appreciate the essential and invaluable, pictorial and subjective element in art. But though photography has not killed painting, its scientific and practical applications broaden every day, as this book is evidence.

The scope of the book is wider than its title would indicate. The first four chapters, of some two hundred pages, are devoted to excellent expositions of the history, optics, physics and chemistry of the subject, by Mr. Gibson, Professor Conrady and Dr. Sheppard. The theoretical explanations are abreast of modern views and mention the difficulty of reconciling the wave theory with the quantum theory of light. Sir William Bragg is appropriately quoted: "For the present we have to work on both theories. On Mondays, Wednesdays and Fridays we use the wave theory; on Tuesdays, Thursdays and Saturdays we think in terms of flying energy quanta or corpuscles." Physical science seems to be on the verge of a fresh generalization. The uses of photography as a scientific and practical implement are described in the rest of the book. Each chapter deals with a special subject and is written by an expert. There are chapters on Astronomical Photography, Photography in Physics, Photomicrography, Photographic Surveying, Aeronautical Photography, Colour Photography, Kinematography and so on. In the chapter dealing with Astronomical Photography Mr. Davidson points out how much the astrographic chart owed to the energy of the late Sir David Gill, so well-known to many of us as H.M. Astronomer at the Cape. For the measurement of the Einstein Gravitational Displacement it is explained that an improvement will be introduced in the photographic method employed, which will enable the absolute displacement to be measured, instead of the displacement relative to that of stars on the same plate not very near the sun's limb.

In the chapter on Photography in Physics we are given a description of the methods used by Professor C. V. Boys in photographing a rifle bullet whilst in flight. [An account of the S.M.E. experiments, of some years ago, for determining the motion of recoil of the rifle itself (*R.E Journal*, January, 1905), might also have been given.] We have, in the same chapter, an account of X-ray Photography, and of the photographing of α particles, with much else of interest.

For the soldier the most valuable chapters are those on Photographic Surveying, by Colonel H. St. J. L. Winterbotham, R.E., and Aeronautical Photography, by Squadron-Leader F. C. V. Laws. The former chapter

* *Photography as a Scientific Implement. A Collective Work.* London, Blackie & Son, Ltd. 1923. 8vo. pp. 546. 30/-.

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is an excellent summary of the development of photographic methods of surveying during the last thirty years, and deals with ground photo-topography, air photo-topography and stereo-photogrammetry. The latter gives much interesting information with regard to aeroplane cameras and their mounting, and about plates and films, the precautions to be observed in taking aerial photographs, and the construction of "mosaics." In view of the recent successful experiments of Professor Melvill Jones and Major J. C. Griffiths, in keeping an aeroplane on an even keel, it may be said that the direct use of mosaics, without correction, promises excellent results for rapid reconnaissance and large-scale exploration. Mr. J. W. Gordon's revival of the method of Taylor (of Taylor's Theorem), for finding the position of the horizon on an inclined photograph, is not mentioned; but then, Mr. Gordon's book has only just been published.

The reader will not easily find another book which covers the same field as that under review and which gives, so clearly and concisely, such a reliable account of the history and physics and of the many applications of photography. There are not many omissions to record. No mention is made of Galton's composite photographs of groups of human faces, which serve to record "types." And, (a more important omission), the archæological use of photography is nowhere indicated. Perhaps the reason for this latter omission is that this particular application has only recently made its appearance above the scientific horizon. The application in question is due to the discovery of the fact that air-photographs reveal features of the earth's surface which are quite invisible on the ground. Ancient tracks, ancient fields, ancient dwellings, show themselves on the air-photograph in an almost magical way. One appears to be looking at the distant past as it were through a veil. This was noticed in Mesopotamia by Lieut.-Colonel G. A. Beazeley, R.E. and others; and Mr. Crawford, of the Ordnance Survey, has, by this means, been able, in certain areas, to construct a map of the fields and roads of pre-Roman Celtic Britain. If we could only go a little deeper and obtain a kind of X-ray photograph of the structure of the earth!

C. F. CLOSE.

MILITARY ORGANIZATION AND ADMINISTRATION.

By MAJOR W. G. LINDSELL, D.S.O., O.B.E., M.C., *p.s.c.*, R.A. (Gale & Polden, Ltd., Aldershot. 7s. 6d.).

Now that the period of grace for promotion, without having passed an examination, is drawing to a close, the appearance of Major Lindsell's book will be hailed with a sigh of relief by officers nearly due for promotion and many others who are trying to keep pace with recent developments. It is strongly to be recommended to all such officers.

At a time like the present, when organization and training are only beginning to crystallize into a more permanent form, after the post-war period of reform, the book is especially valuable.

Already new manuals, new establishments, and new rulings have left some of the detail in Major Lindsell's book out of date; and one must

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all the more admire the courage of this officer in publishing his book at such a time, for it is certain that frequent new editions will be required during the coming years if the book is to remain of use to those for whom it is written.

In certain particulars Major Lindsell, in his position as an Instructor at the School of Administration, may bring us ahead of published policy, but in some important points he differs from the manuals. The following two examples may be quoted:—His description of the organization of No. 1 (the Baggage and S.A.A.) Company of a Divisional Train on page 71, and his explanation of the working of the two echelons of the D.A.C. on pages 86 and 87. Both these run counter to the official publications. Under the circumstances, however, the wonder is that there are not more frequent differences.

The choice between what detail should be inserted and what should be omitted in such a manual is difficult to decide, but one is inclined to wonder what can have guided the author in several cases in his choice. For example, detailed figures are given as to what may be added to or deducted from a man's pay, while the total of what his pay actually is is omitted.

Again, a book which gives a detailed menu of what the soldier should be given to eat for two whole weeks, summer and winter, might be expected to show where and how tools and engineering stores may be obtained in war. In view of the importance laid on the Pay and Mess Book, in recent examinations, more detailed explanations, with examples, might be given of the system of keeping it up.

The book is well arranged in clearly divided sections, with a good table of contents. An index, however, would have been a welcome addition.

The system of references might be improved by giving detailed reference to the authority for each paragraph. The method adopted of giving general references to manuals for a whole chapter is not usually sufficient. The diagrams scattered through the book are excellent, and even more might have been done by their means to add to the conciseness of the information, thus making room for rather more information, of which an officer working for promotion or the Staff College would be glad, considering the comparatively high price of the book.

R.P.P.-W.

CARGO-HANDLING AT PORTS.

A survey of the various systems in vogue, with a consideration of their respective merits. By BRYSSON CUNNINGHAM, D.SC., B.E., M.INST.C.E. (Chapman & Hall. 13s. 6d. net).

LITERATURE on the subject of cargo-handling at ports is, in this country, practically non-existent. A few articles on the subject appear from time to time in technical journals, but apart from these very little information is obtainable as to the principles underlying the art of getting cargoes expeditiously in and out of ships, or of moving goods to and from transit sheds.

The writer of the volume under review has approached the subject from the point of view of the engineer, and has not included any chapters on the documentation and management side of cargo-handling.

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The subject, therefore, though not exactly a military engineering one, will be of value to R.E. officers when viewed from the civil engineer's point of view.

No intelligent person could read the book without being interested, in that it reveals to the uninitiated how the goods that satisfy his daily wants are packed for shipment, how stowed, trimmed, handled, and finally deposited at their destination.

The engineer will read the book with double interest. He has certainly, during some part of his career, had to lift, transport, sort out, and handle stores. In "Cargo-Handling" he will read how these problems are tackled in the ports of different countries the world over.

The subject is treated logically. Cargoes are divided into groups such as Bulk, Special and General cargoes—each kind requiring a different method of stowage in the ship and handling at the port. Ships' gear and quayside gear for handling the different types of cargo are then described.

There is an interesting chapter on quayside cranes. Electric motive power is now in the ascendant for these, and is gradually superseding the hydraulic ram for lifting and lifting-gear, whilst compensated luffing action is the feature of all modern quayside cranes. Such cranes have no great need for large weight-lifting capacity. There is little need to supply cranage power in excess of 1 ton or 30 cwt. This point was certainly not realized at the beginning of the late war, and there still appears an idea in many minds that the ordinary quayside crane is capable of dealing with all loaded wheeled army vehicles.

Quayside cranes are more prevalent and more complicated at ports where tidal influence is most felt. With tidal variations of the order of 20 ft. to 40 ft., a ship's derrick is often below quay-level. A crane on the quay is, however, capable of being mounted so as to be workable at all states of the tide.

In British and North European ports the quayside crane is fully developed, while in New York, and the ports of the Western seaboard of the North Atlantic, the Burtoning system is in vogue, partly on account of the tides, and partly because the quays in these parts of the world are built on piles, and are incapable of taking heavy loadings such as are brought on by crane foundations.

The process of Burtoning consists in attaching the cargo-lifting hook jointly to the end of two lines, and swinging the load between the vertical positions which the lines occupy at the extremities of their range. One line usually is passed over a sheave on the ship's derrick, and the other is passed through a sheave attached to some point well above quay-level. The Burtoning method of handling cargo is quick, expeditious, and makes use of the ship's lifting gear as well as the quayside winches.

Conveyers and elevators present many admirable features for the transport of goods from one place to another, but it is essential that there should be enough work for these appliances, or they become expensive luxuries; a minimum load of 10 tons an hour must be assured. The various forms of conveyer and elevator are well described and illustrated.

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The chapter on trucking goods at the quayside and in transit sheds is interesting, and should appeal to any R.E. officer who has had to deal with large dumps of material. Elevating trucks for use with loaded skids, petrol-driven tow motors for trucking goods, Elwell-Parker trucks deriving power from storage batteries, are all described, and have their performances tabulated and compared.

Stress is laid on the importance of the lighter as a cargo-carrying agent; some 80–90 % of all goods brought to the Port of London being unloaded into lighters, while in New York the figure is 65%.

Interesting descriptions are given of the handling of bulk cargoes such as coal, ore, grain, refrigerated produce, oil, timber and the like together with figures showing comparative efficiencies of the different methods of handling bulk cargoes of the same kind.

The volume is full of interesting facts, it is very well illustrated, and all explanations of different gears and machines are clear and easy to follow.

G.C.G.

DAMP WALLS.

A Handbook on the various causes of dampness in house walls, etc., by ERNEST G. BLAKE, M.R.S.I., A.B.I.C.C. Published by Crosby Lockwood & Son. Price, 8s. 6d. net.

THE dangers to health and property entailed by damp buildings are vividly described by the author in an early chapter, and the rest of the book presents an exhaustive survey of the causes and remedies of dampness. Temporary remedies and palliatives, both internal and external, are described in Chapters III and IV, but the importance of radical and permanent cures is fully emphasized. Permanent remedies and the eradication of the causes of dampness are dealt with very fully in Chapters V to X, including remarks on damp-proof courses, weather-tiling, asphalt, water-proofing compounds, renderings, clay puddle, subsoil drainage, defective sills, flashings and water-pipes.

The use of water-proofing compounds in cement renderings is strongly recommended, and the methods of using hydrated lime, the Sylvester process, water-glass and certain proprietory compounds are described. The relative advantages of powder and liquid water-proofers are discussed, the author considering that the facility with which powders can be transported and proportioned more than outweighs the ease with which liquids can be evenly distributed throughout the mass by adding them to the mixing water.

Chapters XIII and XIV describe various forms of water-proof building construction, including dry areas, hollow walls, perforated bricks, and special forms of monolithic concrete construction. Chapter XV describes fourteen methods of concrete block construction. Chapter XVI deals with cement renderings—for the second time—and describes the use of the Cement Gun. Some notes on *pisé de terre* and other unusual forms of construction are included.

A great deal of information is included in the book, which should be of considerable value to those having the care and upkeep of buildings,

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but it suffers from being presented in a somewhat indigestible form due to the large number of processes described, some of which are not very closely allied to the subject under consideration, while others are deprecated by the author and still described at length. For instance, the practice of covering a damp wall with match-boarding is described as " an ostrich-like policy " which " allays all fears, so that a false sense of security is produced " ; nevertheless, the process is described at length in nearly four pages, including an illustration. A great many proprietory articles and methods are described by the statements made in manufacturers' advertisements, which can only be regarded as a review of the methods and not as the author's recommendations. The general question of the adaptability of various methods to different circumstances is shortly described in one section of the last Chapter, and might advantageously be more fully treated.

As a reference book, the new volume should be of value in any works office, providing, as it does, a complete compendium of information on the subject.

J.C.P.T.

THE LAW OF THE CAR AND EVERY MOTORIST'S OWN LAWYER.

A popular guide for the private and commercial owner and driver. By L. G. REDMOND-HOWARD, author of *Law of the Cinema*, etc., and HAROLD CRANE, LL.B. (Lond.), Solicitor of the Supreme Court. Edited, with an Introduction and Technical Notes, by W. GORDON ASTON, A.I.A.E., A.T.R.AE.S. London, Percival Marshall & Co. Price, 2s. 6d.

MR. ASTON explains in the introduction that " this book has been produced because, in spite of the fact that they are surrounded, circumscribed, harassed, persecuted and bamboozled by the law, motorists, as a class, have never taken the trouble to ascertain anything about it." If the reader drives, owns or deals in private or commercial motor-cars, he cannot fail to find in this small volume an amount of useful information in non-technical language, which he does not but ought to possess. Also, it is probable that he will discover that the law is less of an ass than he thought ; as he will find that it gives him many rights and privileges even though, in some of its restrictions, it may temporarily conflict with common sense.

T.

PATIALA AND THE GREAT WAR.

(Medici Society.)

THIS book, printed for private circulation, has been presented by the Medici Society to the R.E. Corps Library. It is a fine specimen of beautiful printing and photograph reproduction and the tale that it tells of the stupendous effort both in men and money which was made by this famous Sikh State in aid of the Souzerain power, deserves to be remembered for all time to the honour of His Highness the Maharaja.

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POPULAR FALLACIES, EXPLAINED AND CORRECTED.

By A. S. E. ACKERMANN, B.Sc. (Engineering) Lond. 3rd. Edition. The Old Westminster Press. Price, 12s. 6d.

THIS delightful book, of nearly a thousand pages, deserves to take its place beside the *Percy Anecdotes* and *Curiosities of Literature*, as a companion with which very pleasantly to while away an idle hour. Great is Truth, but there is life in many of these old Fallacies yet! Possibly the suggestion that Truth seems "to stand at a fixed centre, midway between its two antagonists—Fact and Phantasm," may apply to some other things besides art. F.E.G.S.

MAGAZINES.

REVUE MILITAIRE GÉNÉRALE.

(*June*, 1923.)—*German Mentality.* By George Blondel, Professor at the School of Political Science.—The writer traces the development of the German school of thought from the days of inter-tribal wars. Tacitus attributed to the Germans a *vis durans*, and native simplicity and exclusiveness delayed their civilization. In the 18th century signs of cosmopolitanism appeared, in the 19th from Luther's doctrine of predestination was evolved the conception of Germany as an elect nation divinely destined to serve as model and guide to nations less favourably endowed—a conception elaborated by Gottlieb Fichte and Frederic Hegel. The latter added the idea that world domination could only be obtained by force. The writer argues that the germ of this idea is to be found in Kant, who taught that organization is indispensable, and that the moral obligation of the individual must cede to the duty of submission to the State. By degrees the Germans have been inspired with respect for constraint and force, until Bernhardi writes that "might is the highest right." Defeat has not altogether abolished these ideas, but there are signs that Prussian blood-and-thunder methods are being subjected to a healthy criticism which may lead to a greater moderation of outlook.

Colonial Warfare, Morocco. By Capt. R. Baillot.—This article is divided into two parts: I., method of conquest and pacification; II., operations. The first describes the country and inhabitants. Peaceful penetration is pursued as far as possible, the Intelligence Officers finding out all they can about the topographical features, especially where water is obtainable, and about inter-tribal relations which may at times be turned to account. II., when military operations are required, a mixed brigade of about five battalions, two squadrons, and two or three batteries of 65's, with hospital and other services, say, 4,500 men and 1,800 animals, has been found to be the handiest force. It has to carry its own supplies, and marches in square, with advance, flank and rear guards, and the convoy in the centre, ready to repel attack from any direction. The advance must be continuous or lately-conquered tribes may be raided by others which have not yet submitted. A perimeter camp is formed at night, for the defence of which Brun entanglement is always carried. To close an operation, a fortified post

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is prepared, communications established, cultivation commenced, and as the tribes show signs of settling down peacefully the garrison is gradually reduced.

The Fatal Quarrel between a Chancellor and an Admiral.—The article by Capt. de Gaulle is concluded. Tirpitz now gained the help of Hindenburg, possiby in exchange for assistance offered to him in obtaining the post of Generalissimo. Bethmann experienced difficulties with the newly-assembled Reichstag, and the Press of the Right pleaded that the most formidable weapon that Germany possessed should not be wasted. Bulgaria having joined the war, Falkenhayn withdrew his opposition for a time, but in March, the situation at Verdun having turned in favour of France, the Emperor's cabinet decided to postpone the submarine war indefinitely. Tirpitz became ill; his resignation was suggested, sent in, and accepted. Popular excitement grew, and manifestations, the first since the mobilization, and the last until the revolution, organized in Berlin in favour of Tirpitz, had to be dispersed by force. Tirpitz now organized a party called the Patriotic Party, which advocated the dismissal of the Chancellor, the annexation of Belgium, and unrestricted submarine warfare.

The Grand Admiral's resignation did not restore Governmental authority over the Navy, and on 24th March the *Sussex*, with several Americans on board, was sunk by a torpedo. Excuses were offered and reparation promised, but the Emperor had himself to reprimand the submarine commander. The heavy blows struck at Germany by the Allies in 1916 checked the propaganda of the Patriotic Party. In August Falkenhayn was replaced by the military dictatorship of Hindenburg and Ludendorff, who began by characterizing submarine warfare as folly, but by October Germany had regained confidence. In November the Chancellor's proclamation of Polish independence annoyed Hindenburg who, in view of the improved military situation, announced that the time had come to renew the blockade of England. Bethmann endeavoured to obtain a respite, announcing his proposal of a general peace, but on receipt of a refusal of that overture from the Entente Hindenburg carried his point, and a Council of War decided to commence unrestricted submarine warfare on 1st February, 1917. Counsels of delay received from Bernstorff at Washington met with no favour, and on receipt of notification of the blockade the United States decided on war. At the very moment when Germany might have obtained advantageous terms of peace she condemned herself to defeat.

Considerations on War of the Future.—This article is a criticism by Commandant Paquet of an article by Colonel Amadeo Guillet, of the Italian General Staff, in the *Rassegna dell' Exercito Italiano* for November and December, 1922. Colonel Guillet advances the view that what he calls the "aero-chemical" arm, aviation and gas, was the one entirely novel characteristic of the late war, and that "the new aerial arm judiciously organized constitutes by itself alone a force capable of deciding a conflict." He imagines Italy "without any land army, but disposing of such a superior air force as would master that of any of her neighbours. This force would cause in the enemy's army, bases and populated centres, such destruction that human nature must

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abandon the struggle." He cites the case of Iraq, where England has replaced a land army by a small air force, and states that the United States have recently discovered a gas of deadly and persistent qualities which would appear to be capable of deciding the fate of a war. In answer to this it is pointed out that the A.A. gun and projector have proved themselves a very effective defence against air-craft, also that any improvement in aviation effected in any country is quickly adopted by its probable adversaries, and after the air fleets have fought it out the big battalions will come to their own. Colonel Guillet then argues that the " potential menace " of the superior air force waiting in its aerodromes will keep the enemy quiet even if its territory is not occupied by any land force. But he weakens his case by referring to an eventual resumption of hostilities by the nation conquered in the air, which presupposes a land army, and if this is the case, what will the country do which has nothing but its air force? It must organize a land army also, and the fact is that war now demands the utilization of the entire resources of a nation, and the best land army, supported by the best air force, will win the day. Colonel Guillet has great faith in his new method of warfare, and proceeds to show what an enormous saving in expense it would cause. He ends his study with a glance at the political and international consequences of an Italy organized for aerial warfare, looks to the air as facilitating the military recovery of Germany, and recommends France to reduce her land army and concentrate on the aerial arm. Italy could deny the Mediterranean Sea to England, and the latter, in view of her interests there, would have to come to an arrangement in return for which she would have to pay heavily in providing Italy with commodities which she needs.

(*July*, 1923.) *Talleyrand and the Open Frontier.* By Commandant Weil.—This is an attempt to fathom Talleyrand's reasons at the date of the capitulation of Paris for not standing out for what has been called the natural frontier of France, the Rhine and the highest peaks of the Alps and Pyrenees. He had a good case, for, prior to the Consulate and to Napoleon's wars of aggression, France had acquired the extended frontier in defensive wars, or at the request of states which had claimed her protection, were still friendly, and spoke her language. Posterity will never cease to blame Talleyrand for his want of firmness. The withdrawal of the frontier from the Rhine to that held by her kings in 1792 has already led to much bloodshed, and may lead to more.

Two Battalion Attacks. By Commandant Janet, from documents supplied by the historical service, and information furnished by combatants.—The two attacks described occurred in September, 1915, one in Champagne, the other in Artois. The events are carefully related, and illustrated by sketches, without which the details would be difficult to follow. Should be read in the original and would afford useful studies for battalion officers.

Strategy and Operations of the Allies in the North.—A continuation of the article by Capt. Kuntz, which traces the operations of the latter end of August, 1914, including the check to the Germans occasioned by the threat to their right flank, and their abandonment of the idea of capturing Lille and Paris and cutting the British communications with Dunkirk

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and Calais, for the direct pursuit and defeat of the English Army. French Headquarters meanwhile recognized where the heavy blow was to fall, and set about restoring the strategic situation by the constitution of a reserve to be formed by the junction of the 4th and 5th Armies with the English and troops drawn from the East, while the remaining armies held the enemy on their fronts. This was a risky undertaking, as all the troops were in contact with the enemy, but was entered upon with confidence. (*To be continued.*)

Swiss Chronicle. By Major de Vallière.—The 7·5 c.m. field-gun, altered by Salzer Bros., of Winterthur, has been made into an excellent mountain weapon. The shield has been strengthened, the axis of the gun raised several centimetres to allow of giving greater elevation, and the trail has been widened and hollowed out to receive the breech on recoil. On level ground an elevation of 410 per 1,000 is obtainable, and at an altitude of 2,000 ft. on a slope of 11°, and with an elevation of ·6 per cent., a range of just over five miles has been obtained with the normal ammunition. The firer's and aimer's seats fold up on the trail for facility of carriage. Dismantling and assembly each take ten to fifteen minutes with six trained men. The gun and carriage make nine loads capable of transport on light carts, sledges, or by hand, into the highest mountains. Charges of different weights allow of fire on all varieties of ground.

The Federal Council has constituted heavy artillery regiments each of two groups of 12-cm. guns on tractors, and a group of 15-cm. horse-drawn howitzers.

A steel helmet has replaced the képi-shako for all arms.

Le Rôle du Général Gallieni (Août–Septembre, 1914). By Paul Pilant.—Written with an evident desire to elucidate the truth, this book is based not only on official documents, but on second-hand and partial information, and conversations of no military value. It refers to "resistance" on the part of Gallieni, and "hostility" on the part of Joffre, where there was only loyal co-operation. Facts are, however, presented with accuracy.

Nieuport, 1914–1918. By Commandant Robert Thys. (Berger-Levrault).—An instructive history of actual events related with indisputable technical knowledge, describing the inundation of the Yser, and all the works connected with them. The book is a work of art, illustrated with admirable photographic views, maps, sketches, portraits, and coloured plates.

Histoire de la Guerre navale, 1914–1918. By Lieutenant de Vaisseau de Rivoyre. (Fournier.)—This work aims at affording young officers, not a complete history, but an exact abridgment—a frame into which facts can be fitted later as they become better known. It is divided into two parts, the first historical, illustrating the intimate relations which must unite strategy and politics, including economic considerations. The second part gives accounts of the principal naval actions, and the lessons they teach. A book of predominant interest.

L'Apocalypse russe. By Serge de Chessin. (Plon.)—A masterly account of the Russian revolution from the Red Terror and formation of the Third International to the final triumph of Bolshevism.

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Mémoires du Kronprinz. (Payot.)—A sensational publication, but one which does not reveal much that was not known, or guessed, already. A few obscure points are cleared up, and the Emperor and his son are delineated, such as they were, and both, consciously or unconsciously, responsible for the war. Their relations, if generally correct, were not very cordial, and the son speaks unkindly of his father—possibly a Hohenzollern trait. The book may be popular in Germany, as the Crown Prince is a thorough German, and a few passages which have been well received by various newspapers are the most interesting. As to the rest, the personalitities of the Emperor and Crown Prince evoke a certain sympathy owing to the misfortunes which have overtaken them, and which they in no way understand, but neither had the force of character to guide the events he should have controlled.

(*August*, 1923.)—*The Tactical Employment of Infantry Automatic Weapons.* By Lieut.-Colonel P. A. Cour.—A fairly exhaustive study of the tactical use of automatic rifles, and light and heavy machine-guns in support of advancing infantry, contrasting German and French methods of attack and employment of their weapons in furtherance of their respective ideas, but omitting any remarks on their use in tanks and in defence. The article is worthy of perusal by all concerned with the employment of these weapons in the field.

A Flank Attack. By Major Charbonneau.—This article describes the flank attack made by the 1st Colonial Corps, on 16th April, 1917, against the Germans north-east of Soissons. The attack, delivered in an easterly direction, was intended to facilitate the northerly advance of the 6th Army during General Neville's ill-fated operations on the Aisne, which ended in failure.

Tactics and Army Organization. By Major Pamard.—This article belongs to the series entitled *Introduction to the Study of History*, and as such is of interest. The writer observes that the object of war is to break the adversary's will and induce him to accept certain conditions. Up to the French Revolution armies consisted mainly of mercenary troops, which were expensive to maintain and took some time to replace; it was therefore the sovereign's aim not to waste them. Pitched battles were seldom fought, and the capture of an important town or province usually sufficed to bring the vanquished to terms. A battle, when fought, was a confused mêlée in which individual bravery and skill met their reward. When fire-arms were invented the mêlée became a more difficult problem, and it was evident that the destructive effect of the new arms must be developed, and that movements must be made in formations as little vulnerable as possible; hence the inception of tactics which involved precision and more perfect organization. The evolution of French army organization and tactics from the 18th century onwards to the present day is then sketched, showing Napoleon's influence on the Art of War.

Le Grand Etat-Major allemand avant et pendant la guerre mondiale.—An analysis and partial translation by General Douchy of the book by General von Kuhl. Von Kuhl's book, *Der deutsche Generalstab in Vorbereitung und Durchführung des Weltkrieges*, was published in Berlin, in 1920. General Douchy has not given a verbatim translation. He

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has more particularly investigated the history of the various plans formulated by the German Great General Staff since 1871 in view of the possibility of having to face at the same time enemies to east and west. The tables and statistics given in the German work are not reproduced, as the French author suspects that they have been compiled merely for the greater glorification of the German General Staff. "With all due deference," he says, "to General von Kuhl, his book is only a piece of special pleading." Bearing these points in mind, General von Kuhl's words are of powerful interest, for he was better placed than anyone else to know what was going on, owing to the high appointments he held before and during the war. The most interesting part of his book is his narration of von Schlieffen's plans, and of the modifications of them introduced by von Moltke the Younger. Another remarkable passage is that in which von Kuhl deplores the decease of the Great General Staff. In regard to this General Douchy remarks that the fact of the existence of such books as this clearly proves that, if the Great General Staff has been officially suppressed, its spirit still lives, and it is probable that at the moment of need its principal elements would very quickly be reunited to produce a formidable organism.

A. R. REYNOLDS.

REVUE MILITAIRE SUISSE.

(*Nos.* 5 *to* 9 *inclusive.*)

The operations of Sordet's Cavalry Corps in Belgium during the period August 6th to 15th, 1914, have been the subject of severe criticism. A work entitled *Historique du Corps de Cavalerie Sordet* has recently been published in Paris (Chas. Lavauzelle et Cie); its author, Colonel Boucherie, who has compiled the book under the supervision of General Sordet, has set out facts culled from official documents in diary form, but has made no attempt to search out and record the lessons to be learnt from an investigation of the handling of this cavalry force. A formulation of these lessons having been left for others to undertake, Colonel Poudret has applied himself to the task and contributes an interesting article to the *Revue* (Nos. 5 and 6), wherein the situation on the Western Front at the opening phase of the Great War is closely examined by him. The now famous plan XVII of the French General Staff contained a secret instruction dated February 7th, 1914, wherein was given the composition of the future 1st Cavalry Corps, its mission and its concentration area. Sordet's Corps was to assemble in the neighbourhood of Montmédy and was, at first, to support the French II Army Corps should the Germans attempt an offensive in the northern part of the Woëvre region; alternatively, in the event of an invasion of Belgium by the Germans, the Corps, which was to be supported by a small infantry force, was to march into Belgium. In the latter event, the mission of Sordet's cavalry was to get at once into touch with the enemy's columns, more especially those advancing from Belgian Luxemburg, to the southward of the difficult region about Houffalize and St. Hubert; its task was to obtain intelligence and at the same

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time to delay the advance of the enemy to as great an extent as possible. On March 9th, 1914, General Sordet drew up his plan of operations—an outline of it is given in No. 5 of the *Revue*—which was approved by the French Commander-in-Chief-designate. On August 2nd, the units of the 1st Cavalry Corps took up their stations as provided for in the "*ordres de couverture*." That there was wastage in the Corps during the operations that followed, and, indeed, that it was excessive, is admitted in almost every quarter. Colonel Poudret endeavours in his article to elucidate whether or not this enormous wastage was inevitable owing to the nature of the mission imposed upon Sordet's Corps, and examines the situation critically, with a view to ascertaining how far the wastage could have been avoided altogether, or, at least, minimized. For this purpose, the course of events is analysed, and the directives and orders issued are dealt with in detail. It is pointed out that, whatever doubts the French may have had before the outbreak of war as to the intentions of the Germans, these were removed in the first days of August, when the latter sent their ultimatum to Belgium, an ultimatum which was quickly followed by the invasion of Belgian territory. The question then arises whether, in view of the indications thus given of the probable direction of the German advance, and of their plan of campaign, the instructions issued to General Sordet should have been immediately modified or not. It is admitted that an attack on Liége did not necessarily imply that the Germans intended to operate along the left bank of the Meuse; however, such an attack made it almost certain that the advance of the outward flank of the German right wing would be directed along a latitudinal zone northward of that in which lay Sedan. Clearly then, the sector between Sedan and Namur became at once suspect and required to be watched with the greatest care. Colonel Poudret's view is that, having regard to Germany's ultimatum to Belgium and the attack which was directed immediately against Liége, it would have been a wise precaution to have at once modified the instructions given to General Sordet, and his Corps should have been sent, *via* Givet or Dinant, towards Rochefort. He points out also that, had the German advance on Brussels been foreseen prior to the outbreak of hostilities, it would have been necessary to plan the strategic deployment of the French Army quite otherwise than was provided for in the scheme actually adopted (plan XVII), and in that event Namur would have been the proper concentration centre for Sordet's cavalry; from there both banks of the Meuse could have been effectively reconnoitred, and, at the same time, measures could have been carried out for the closest possible co-operation of the French and Belgian Armies, and they could have then been favourably placed to take part together in a general battle in some selected position, where the advance of the German right wing might have been successfully barred. Colonel Poudret unreservedly condemns the raid on Liége attempted by Sordet's Corps; he is of opinion that such a mission was altogether an improper one to assign to the French cavalry in the particular circumstances. At the time that the raid was undertaken it was more important, he thinks, for the French cavalry to explore in an eastward than in a northward direction. To the suggestion that a

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diversion in the neighbourhood of Liége by the French cavalry would probably have prompted the idea of the existence of complete solidarity on the part of the Allies, and thus heartened the defenders of the Belgian fortress, Colonel Poudret replies that the silence of the "canon libérateur" which succeeds its roar and betokens the failure of a relieving force to achieve its purpose has a far more discouraging effect on a besieged garrison than the temporary encouragement derived from the knowledge that help may be at hand. His view on this point is perfectly sound. In summing up his analysis of the facts brought to light in Colonel Boucherie's book, Colonel Poudret expresses the opinion that the failure of Sordet's cavalry was due not only to faulty directives and orders issued subsequently to the initial instructions of March, 1914, but to some extent also to defective peace training: the French cavalry soldier was, before the Great War, very conservative; he admitted the possibility of his arm being required to fight dismounted, but was averse to the adoption of a mode of warfare—and consequently, also, to the training necessary—which was at variance with methods of fighting conforming with the cavalry spirit of old time. The cavalry soldier's peace-time training was also responsible for certain other mischievous consequences. Having become habituated to the working out of its special missions, unaided by the other arms, in positions well in advance of the main army, the cavalry had lost the instinct of co-operating with those other arms, and, therefore, did not dream of profiting from the substantial help that the other arms were capable of affording it in the situations that actually came to pass. For instance, support could readily have been obtained by Sordet's cavalry, on August 13th, from Lanrezac's Corps, which had been opportunely directed by its Commander on Dinant; however, no advantage was taken of the presence of this large mixed force by the French cavalry leader for the purpose of consorting measures which would probably have enabled the French to inflict a very serious, if not crippling, blow on the German cavalry.

An article on aviation and gas warfare is contributed to No. 5 of the *Revue* jointly by Captain Primault and R. A. Jacques. Therein it is pointed out that the use of poison-gas for the purposes of warfare is so recent that a very vivid imagination is required in order to plan out future developments in connection with the employment of this weapon. The tactical results obtained by the use of poison-gas were, it is claimed, enormous, and it is predicted that the strategic results likely to be obtained by a proper development of this arm will, in a future war, be very striking; indeed, it is suggested that the further developments in the gas-attack will completely modify the lines upon which campaigns have hitherto been planned. It is in the direction of extending the radius of action of the gas-attack that all efforts should, the authors of the original article think, be turned in order that powerful surprise effects may be obtained not only along an opponent's firing line but also in his "back areas." It is to aircraft that they look as the means for effectively increasing the range in gas-attacks and for securing, by surprise action, strategic results on a vast scale. It is claimed that by means of gas-attacks carried out by aircraft the munition factories

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in enemy country can be entirely brought to a standstill immediately on the declaration of war. It is suggested that the side possessing the stronger Air Force will be able, at the very outset, entirely to crush, by means of combined operations on the part of the Fifth and Sixth Arms, all preparations attempted to be carried out by an enemy behind his *troupes de couverture*. The claim is a very large one and seems to predicate that one's enemies are likely to be more supine than they have ever before proved themselves to be. Yet, it is recognized by the authors of the original article that many methods of anti-aircraft have been devised; however, they assess at small value the efficacy of the defence measures against gas and aircraft developed up to date and justify the views held by them by pointing out that, after four years of training under the most practical conditions, anti-aircraft artillery at the end of 1918 expended on an average some 7,700 rounds for each enemy aeroplane destroyed. It is further argued that, if gas measures should be adopted in the future as a means of defence against hostile aircraft, such measures are not likely to meet with any greater degree of success than was achieved by the anti-aircraft artillery in 1918. The matters dealt with in the original article are of high importance, and need careful study on the part of specialists.

Colonel Lecomte contributes an interesting article to No. 9 of the *Revue* on certain *Hérésies stratégiques*; these require to be carefully noted. The majority of the remaining articles in these numbers of the *Revue* are of more particular interest to the Swiss Army, and concern the Swiss people rather than the foreigner.

W.A.J.O'M.

BULLETIN BELGE DES SCIENCES MILITAIRES.

(*Nos.* 8 *to* 10 *inclusive*).

The account of the operations of the Belgian Army in 1914 is continued in the numbers of the *Bulletin* under notice; the events of October 4th being dealt with therein. The principal preoccupation of the Belgian High Command at this time concerned the measures necessary to secure the safety of the lines of communication of the Belgian Field Army then at Antwerp. In a written communication sent by the Belgian War Minister to the British First Lord of the Admiralty, it was stated that the Belgians would offer resistance at Antwerp to the extreme limit of their power, and it was suggested that, if, in addition to the Royal Marines already taking part in the defence of the fortress, any further British reinforcements were to be provided, it was preferable they should be directed on Ghent rather than that they should be pushed into the fortified zone of Antwerp. Incidentally, the narrative discloses the fact that the views of Lord Kitchener and F.M. Sir John French, as to how best the Belgian request for help was to be met, were widely at variance. Eventually the British Government decided to make an attempt to reinforce the Belgians without delay, and the 7th Division and the 3rd Cavalry Division—the only troops immediately available in Great Britain—were detailed for this purpose and ordered to Belgium. At this time, the II Corps of the B.E.F.

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was in process of being relieved by the French at Soissons and was being transferred to St. Omer; simultaneously, the Germans were pushing their artillery attack on the detached works in the southern sectors of Antwerp. The quality of the Belgian fortress troops detailed for the defence of Antwerp was poor, and the knowledge of this fact was undoubtedly causing the Belgian High Command considerable anxiety. Fortunately, the Germans still had a wholesome respect for the Belgian fortifications and were acting with considerable caution; they were not for risking an assault on the fortified zone until their heavy artillery had had full opportunity of making its weight seriously felt. However, whilst the big guns and howitzers were pounding away at the forts and intermediate works on the banks of the Nethe, von Beseler, who had been reinforced by the 1st Ersatz Brigade, carried out a reconnaissance in force in the direction of Schoonaerde, in order to ascertain the dispositions of the Belgians along the banks of the Scheldt. The Belgian 4th Division had by now taken up positions along the river with a view to barring the enemy's advance on Ghent. The Belgian Cavalry was so impressed by the German operations along the Scheldt that (on the evening of October 4th) it was convinced the movements of the enemy all pointed to an immediate attempt being made by the Germans to force the passages of the Scheldt along the line held by the Belgian 4th Division and reported to Headquarters accordingly.

Captain Kuntz has contributed an article entitled *Stratégie et opérations dans le Nord* to the *Revue militaire générale française* of May 15th, 1923; therein he finds fault with the handling of the Belgian Army in the early phases of the Great War, and, in particular, questions the wisdom of the decision taken by King Albert to withdraw his Army from the Gette on August 18th, 1914, instead of accepting battle in that position. These criticisms are resented by Colonel A. E. M. Nuyten, who contributes to No. 10 of the *Bulletin* an article entitled *Ce fut-il une erreur de replier l'armée belge sur Anvers au mois d'août* 1914; therein he warmly defends King Albert's strategy. In his examination of the operations of the Belgian Army, Captain Kuntz lays emphasis on the fact that the Germans were held up for eight days only at Liége; he alleges that a mere threat on the part of the German VII Corps caused the Belgians to abandon Namur; he suggests that the shelter of Antwerp proved mischievously alluring to the Belgian Field Army; he regrets that the advice of the French High Command was not sought before the decision was taken to withdraw the Belgian Army into Antwerp, and expresses the opinion that, in retiring to the famous fortress, the Belgian King was not acting in consonance with the plans matured by the French High Command in the period immediately preceding the outbreak of hostilities. Colonel Nuyten contests the views of Captain Kuntz in relation to each of the points mentioned above *seriatim*, and gives the reasons why the Belgian Army retired on Antwerp instead of endeavouring to join up with the Allies at Mons or Lille. The Belgian Army certainly ran the risk of being cut off from the Anglo-French Armies by taking the northern route to the coast, but the fact remains that it managed to get away from Antwerp and joined up safely with

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the Allies on the Yser, after having succeeded in drawing five German divisions—some 75,000 men—and the German heavy artillery, which was very powerful, to Antwerp; it thus prevented this force from reinforcing the German Armies during the Battle of the Marne. Captain Kuntz is not impressed with the value of the sorties made from Antwerp by the Belgians and suggests that it was not until the end of November, 1914, that they took an effective part in the battle line. In his reply to Captain Kuntz, Colonel Nuyten points out that during the period October 15th to 31st inclusive the losses of the Belgian Army amounted to 16,000 out of a total of 48,000 infantry; further, at this time it was the Belgian Army that barred the northern approaches of Dunkirk and Calais and prevented the Germans from crossing the Yser. Colonel Nuyten quotes statements made by von Kluck, von Falkenhayn and others in support of his view that the strategy adopted by King Albert was sound, and that the retreat of the Belgian Army to Antwerp served the interests of the Allies as well as meeting the particular needs of the Belgian people. The original article deals in an able manner with a highly controversial subject, and is, in consequence, a contribution of considerable value to students of military history.

An article has been contributed to the *Bulletin* by Colonel A. E. M. Fastrez wherein it is shown how important it is that a General Staff should, when framing a plan of campaign, give the fullest consideration to the several political considerations that may be involved. The quarrels between Germany's military leaders and her professors on the subject of the violation of Belgium's neutrality have provided Colonel Fastrez with ample materials for his article, the first part of which appeared in No. 7 of the *Bulletin*. It would appear that so little did the Great General Staff value the opinions and advice of those outside its own immediate circle that officials so highly placed as German Ambassadors and von Tirpitz, the Minister responsible for Germany's navy, were not consulted in relation to certain matters of a political kind concerning which one would certainly have expected a General Staff to seek their views. In his Memoirs von Tirpitz goes so far as to aver that it was not until war was actually declared that he first had knowledge of the intention to march German Armies through Belgium. Colonel Fastrez's article is concluded in No. 8 of the *Bulletin;* he there asks the question: "Was it not possible to avoid the political obstacle?" In examining the situation, Colonel Fastrez points out that the German plan of campaign had serious disadvantages, which were partly political in their nature and partly military. Of the difficulties which the German General Staff was creating for itself, the most important among them was that arising from the projected invasion of Belgium, since such a step would with almost absolute certainty draw Great Britain into the conflict. It may be that the German High Command felt confident that it would be possible to knock France out of the ring before any intervention on the part of Great Britain could become effective. Nevertheless, before taking the decision to march the German Armies through Belgium, the German High Command should have carefully weighed the effect of the possible resistance of the Belgian Army on the operations of the German Army in the event

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of any part of their plan miscarrying. If it is really the case, as is alleged by the German General Staff, that it was not expected that Great Britain could, in any circumstances, have been induced to remain neutral, it became particularly important that Germany should at least, by diplomatic means, have secured a benevolent attitude towards herself on the part of Belgium. Speed and surprise were the two elements most necessary for ensuring success for the German plan of campaign. It was with a view to satisfying the first of these requirements that, according to the German General Staff, the decision to invade Belgium was taken and a plan adopted whereby Germany was, from a political standpoint, placed in the worst possible position; the result was that developments followed which proved fatal to the strategic needs of the Central Powers. Colonel Fastrez examines the conditions existing in the autumn of 1914 along the eastern frontier of France and shows that, with the powerful siege artillery possessed by the Germans they would probably have found the French fortified zones quite as vulnerable as the Belgian defences at Liége, Namur and Antwerp actually proved to be. The fortifications designed by Séré de Rivière in 1875 were quite obsolete in 1914 and no longer met the needs of the situation; their armament also was much out of date and would have been no match for the German siege artillery. In view of this condition of affairs one is justified, says Colonel Fastrez, in asking whether the frontier of France immediately contiguous to Germany was really so redoubtable as the Germans have alleged? The suggestion is made in the original article that the Germans made a great deal of the supposed strategic difficulties of a direct advance against France from Alsace-Lorraine for the mere purpose of covering their political designs against the independence of Belgium, and that alone. Should such have been actually the case, then it can certainly be said the German General Staff succeeded in their plan of campaign in harmonizing their strategy with the political considerations. However, a bold strategy was necessary to support an audacious policy embracing wide aims. It was here that the German plan of campaign, in Colonel Fastrez's opinion, failed: finding that the means available for pursuing their political aims were inadequate, the Germans should, in the initial stages of the war, have been careful to narrow down their aims to bring them within the range of their means. Had the course of events justified their doing so, the Germans could, at a later period, have broadened their objectives. Colonel Fastrez deals briefly with the offensive of the French 1st and 2nd Armies in August, 1914; he thinks that, had the Germans launched a counter-offensive in Lorraine after the collisions between the opposing armies in the neighbourhood of Morhange and that of Sarreburg, they would have met with a large measure of success. Indeed, he goes further than this; he is convinced that, had the German Army made a direct attack against France in August, 1914, without traversing Belgium at all, it would have decisively defeated the French Army. In adopting a course such as that last mentioned, Germany would have avoided the political mistake which led to the resistance of Belgium, brought about the immediate intervention of Great Britain and gave rise to all those consequences of a

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political, moral and military kind which were the proximate causes leading to the defeat of the Central Powers.

Major Jobé deals, in Nos. 9 and 10 of the *Bulletin*, with the Battle of the Marne and the Race for the Sea as studies in the application of the correct principles in the conduct of a modern battle. It was on August 24th, 1914, obvious to all who had knowledge of the facts that the French plan of campaign had completely failed and that the adoption of an entirely new plan was necessary if the war was to be continued to a successful issue. At the same time, events on the Sambre had, to some extent, caused the calculations of the German General Staff to be upset. However, the German High Command was able in great measure to continue its operations on the lines planned for the initial deployment; the enveloping movement against the Anglo-French Armies was pushed on and an attempt was made to exploit the success gained against the French right at Morhange by an energetic pursuit in Lorraine. The directives issued by German Headquarters on August 28th and September 4th, and those issued by the French Headquarters on September 1st and 2nd, with a view to meeting the new situation are set out in the original article. Marshal Joffre's directives provided for the possibility of a retreat to a line as far south as that of the Seine; bitter criticism has been directed against the new plan of the French Generalissimo. Major Jobé defends the new plan; he rightly points out that what Marshal Joffre did was to fix the extreme limit for the retreat of the Anglo-French Armies, which is by no means the same thing as ordering a retirement to the Seine. The French Commander-in-Chief was playing for safety and not disposed to take hazardous risks; in acting thus, he was correctly applying the proper principle in the conduct of a battle, the one without which victory is unattainable. The Germans, on the other hand, by continuing to carry out their original plan of a double envelopment of the Anglo-French Armies had to stretch out their two wings; these both became, in consequence, too weak effectively to crush the Entente Armies between them. The numbers of troops fighting on the two sides at the Battle of the Ourcq are set out in No. 10 of the *Bulletin*; the Anglo-French forces numbered 475,000 men and 1,344 guns (9 Corps), whilst the Germans had only 280,000 men and 1,008 guns (7 Corps). Major Jobé examines in some detail the directive issued by the German Headquarters on September 4th; he is of opinion that it was then impossible for the German Armies to carry out the moves ordered therein and gives his reasons. He also records his conclusions as to the course the German High Command should have followed at the outbreak of war, namely, (1) the Russian front should have been completely neglected until the French were definitely defeated—the adoption of this course would have released four additional German Army Corps for employment on the Western Front; (2) on the Western Front an enveloping movement should alone have been attempted by the northern wing of the German Army; (3) a defensive battle should have been fought by the remainder of the German Army with a view to holding the Entente Armies along the whole length of their front.

W.A.J.O'M.

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MILITÄR WOCHENBLATT.

15th March, 1923.—In the issue of 1st March the *M.W.B.* reviewed Dewar and Boraston's book dealing with Earl Haig's share in the Great War. In the issue of 15th is a leading article dealing with the reception of this book by the French technical Press and particularly by *La France Militaire*. The reviewer observes that this paper is especially concerned with the fame of Marshal Foch as a great Commander " and anxiously watches to see that not a twig shall be taken from his crown of laurels." The reviewer says that the credit for the successful allied offensive in August and September, 1918, is claimed by the English book for Earl Haig, while the French claim this for Foch.

The details of the review of the book and of the French criticism are not of particular interest ; they serve mainly for an attack on the French critic, Gen. Fonville.

In dealing with the " decisive " application of the main body of the American forces under Pershing, after the capture of the salient of St. Mihiel, on the west bank of the Meuse, the reviewer says that this, according to the English book, was to be ascribed to Haig's plan, while Foch would have wished to attack on the east bank in the direction of Briey. " According to other sources " on the other hand, Pershing favoured the attack west of the Meuse, and this plan was selected. " Now there can be no doubt that the direction of attack east of the Meuse, that is to say, the prosecution of the successful offensive of St. Mihiel and its extension, had been the most favourable for operations, and would have caused the greatest difficulties to the Army group of General Gallwitz. On that account the Germans reckoned that the attack would be continued there. To meet these dangers, most of the available German reserves were applied in this direction." The reviewer then goes on to say that Foch was right to act as he did, for he could not tell what success would attend the simultaneous attacks west of the Argonnes and in Champagne where the French were without American aid, adding that on this portion of the great battle-front the French had to thank the " dashing spirit of attack " of the Americans between the Meuse and the Argonnes almost entirely for their successes.

The reviewer then compares Foch's strategy of " Une poche qu'on bosselle à coups de poing " and the " Buffalo strategy " of Ludendorff as criticized by the French, finding a similarity between the two ; he defends Ludendorff against the accusation of the French critic that he never, in his strategy, conceived anything but the attack straight to his front by referring to Tannenberg, the Masurian Lakes and Lodz. He finishes with the observation that, but for the Americans, Foch would have been miserably beaten, and that the French, " particularly chauvinists of the calibre of M. Fonville," do not like to hear this.

The question of the best anti-tank weapon for infantry is evidently of much concern to the German military mind. The ball is thrown in by a writer in this issue, and play is continued in several later issues. In this the writer begins by defining the task of the " Infantry gun " : " From the beginning of the fight in co-operation with the other heavy weapons of the infantry to help in breaking down local resistance and to subdue single machine-guns, machine-gun nests, trench mortars,

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guns and tanks." The need of rapid effective action, before hostile artillery fire has been drawn on to them, is stressed, while the difficulty of ammunition supply is referred to. " An army, which must defend itself against hostile tanks, whilst itself deprived of both tanks and fighting aeroplanes—which can take on a part of the tasks of the infantry gun—has need more than any other to study carefully the question of the infantry gun." The war proved that projectiles of small calibre have not sufficient effect ; the guns which the allied armies now favour are then named. While these appear more or less to agree, it is necessary to be quite clear as to whether the infantry gun is to be used in conjunction with, or against, tanks. In the first case, if necessary, a light trench mortar can be made to suffice ; in the second case, however, a comparatively heavy cannon is required capable of opening fire rapidly, and strongly constructed. An anti-tank gun for short range only is a contradiction in terms and a sheer impossibility.

The writer then goes on to say that while it would be very nice to have an anti-tank gun as well as the " infantry gun," there would be the difficulty that a special anti-tank weapon is ill-fitted to deal with other objectives and at the critical moment would not come into action at the right moment or in sufficient numbers. " For German conditions —weak artillery—this way is not open to us, even if we were allowed to develop artillery."

For an infantry gun that will be effective against tanks the writer requires :—

1. Sufficient effect against living targets and tanks, in so far as this can be attained with a flat trajectory.
2. Adequate provision for ammunition supply.
3. Light mobility, particularly of the weapon when prepared for firing, and the offering of a small target.
4. Accuracy.
5. Great rapidity of fire.
6. The ability to fire from concealed positions.

Each of the above desiderata is then discussed, and finally certain experiments in other countries are commented upon.

In the same issue appears a review of a book entitled *The German Tanks in the World War*. It begins by observing that the Great War has been described as the war of lost opportunities, and adds that this must, at any rate, be admitted so far as the German tanks are concerned. The value and the danger of tanks were greatly underestimated. This applies not only to the measures for defence against enemy tanks, but especially to the construction of German tanks, which " unfortunately " was undertaken too late. Of war experience in actual fighting with the German tanks but little was gleaned. The author of the book reviewed belonged to the German tanks and gained practical experience in the war. Each tank carried the enormous crew of 23 to 26 men, with one gun, 6 heavy and 1 light machine-guns as well as large quantities of ammunition. Each track was driven by a separate motor. The chapter on " The Tank of the Future " is said to be most instructive.

At the end of the war the Germans had only 3 German and 6 captured tank detachments, each of 5 tanks ; that is to say, 45 tanks in all ;

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their first efforts at tanks in the field came at the beginning of 1918. England, on the other hand, started in with tanks in September, 1916, and in October, 1918, disposed of 6 Brigades with 18 Tank Battalions, while France in November, 1918, had over 27 Battalions (1215) of light tanks. " This start in the construction of tanks could not, unfortunately, be caught up by Germany in consequence of the already excessive overstraining of all her forces in the last two years of the war."

In the column giving snippets of news of foreign armies and navies, the following appears under the United States : " The Court of Appeals has acknowledged the sinking of the *Lusitania* as a justifiable act of war. It accepted the transport of munitions on the ship as proven."

1st April, 1923.—The leading article in this issue, on " The French in the Ruhr Territory and Germany," is from the pen of Lieut.-General von Cramon, who has fairly let himself go. The first paragraph runs : " When to-day one takes up the newspapers and reads of the wrath of the French in the Ruhr, or hears the tales of inhabitants of the occupied territory, eye-witnesses of the terrible goings-on there, one believes oneself to be not merely set back into the hoary Middle Ages, but into those former times when savage peoples, who knew neither right nor law, gave unrestrained play to their passions and impulses." Further on, England gets the benefit of quite a long paragraph of the General's abuse. She ostensibly took the part of " our enemy " because Germany infringed Belgium's neutrality, yet to-day she suffers the occupation by France of the peaceable Ruhr although she disapproves of this outrage. Italy is next dealt with ; she is seeking only her own advantage. Whoever counts on America is building on sand. " When it was a question of saving the milliards at stake in the Great War, a *casus belli* was soon found ; to-day, when it is only Germans who are being tortured in this inhuman way, one can remain cool even to the heart and consider it better not to get oneself mixed up in European affairs." The General then has a go at General Nollet and the Military Commission of Control, and ends up with the exhortation to oppose all the demands of the French with " no," " and, if we are driven to extremes, with our ancient Germanic force to fight and win our place in the sun."

Three whole columns of this issue are devoted to a reply to the article in the last number on the question of the " infantry gun." This article defends the claims of the 3·7 cm. gun, which displayed an apparently striking superiority over the German, French and English light trench mortars in some extensive trials against machine-gun nests at ranges of from 800 to 1200 metres ; the report on these trials was not published, but the writer claims to have been given all the information by a friendly neutral. The article is interesting but too long to review in detail. The point he makes at the end is : " Has it really been quite forgotten what it means to the morale of the infantry and their power of resistance if the anti-tank defence is fought by guns withdrawn on the average 1200 to 1800 metres behind the front line, or by weapons from the very middle of the infantry line of resistance ? Before everything in the grey of the morning, with artificial or real mist, or in high corn as on 18-7-1918 ? "

E.G.W.

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MILITÄR WISSENSCHAFTLICHE UND TECHNISCHE MITTEILUNGEN.
September–October.

THE battles on the Carpathians, from the middle of January to the end of April, 1915, are described by Colonel d. R. Mayern in this Austrian Journal. Operations were to take the form of an attack over the Carpathians from the Rumanian frontier to Czeremcha–Strasse in three sectors—on the right (East) v. Pflanzer-Baltin with 6 Infantry and 1 Cavalry Divisions, centre v. Linzingen with 6 Infantry and 2 Cavalry Divisions and left v. Boroević with 14 Infantry and 4½ Cavalry Divisions —v. Boroević was to keep 5 Russian Infantry and 1 Russian Cavalry Divisions, on his left, busy with 4 of his own Infantry and 2 of his Cavalry Divisions, while he attacked 9 Russian Infantry and 4 Cavalry Divisions with the remainder of his group. V. Linzingen had but 1 Infantry and 2 Cossack Divisions opposite him, and v. Pflanzer-Baltin had 2 to 3 Russian Reserve Divisions and 2 Cossack Divisions opposite. The Russians were surprised, but, helped by the weather (a temperature of −20° Centigrade is quoted), soon brought the advance to a standstill. A Russian counter-attack made little progress against v. Linzingen, but its chief weight fell on Boroević and forced his line back by 20 kilometres or so. The XVII Corps from the IVth Army and the VIII Corps from Serbia were sent up to reinforce v. Boroević, and relieved some of the pressure, but the Russians continued to attack with heavy reinforcements, and made it impossible to relieve worn-out 3rd Army divisions. The attack on the right wing, however, prospered. The Bukovina was cleared of Russians and, with right shoulder up, v. Pflanzer-Baltin reached the line Stanislav–Kolomea–Czernowitz by the 20th of February. Meanwhile a new Russian Army was concentrating west of Stanislav: it was impossible to push reinforcements up to v. Pflanzer-Baltin fast enough to guarantee, against fresh troops, the exploitation of his original success and a renewed offensive in the centre was therefore arranged for by pushing in a new Army (2nd) under v. Böhm Ermalli on the night of the 3rd. On the 27th the new 2nd Army attacked in the direction of Baligrod with the idea of relieving Przemysl, but made little progress. Attacks developed along the whole line and from the 1st to 15th of March the casualties of the 2nd Army rose to 51,000. On the 15th the attack was broken off, having done little but draw in the Russian reinforcements destined to counter-attack v. Pflanzer-Baltin. The 2nd Army had drawn upon it the principal Russian forces on this front and now bore the brunt of their counter-attack. Ground had to be given, but the Russians were fought to a standstill as much by difficulty of supply as by opposition, and by the middle of April the battle ceased nearly on the line of January. In this area 1,000,000 Germans and Austrians had held 1,500,000 Russians, whilst further west and north 263,000 Germans had held 608,000 Russians. The sketch diagrams illustrating this article are excellent.

Major Kaiser, whose name in connection with Artillery Intelligence, and the German Artillery School at Wahn, was well known to us during the war, contributes an interesting article on the surveys of targets and of the guns which engage them. Unfortunately it seems to be the concluding part of a series which would repay study. He recommends

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that location units (flash-spotting, sound-ranging, etc.) should be kept separate, whilst the domestic survey—the survey of gun positions, the determination of " line " or bearing, and accurate " ranging "—should become one of the normal duties of the artillery. He advocates ranging on a high burst, and considers that it can be made part of a regimental routine by arranging for chains of surveyed O.P.'s after the manner of a flash-spotting section. The flash-spotting section and sound-ranging section of a division should be put in the advanced guard, and should be ready with surveyed targets for the divisional artillery on arrival—a most ambitious programme. Wireless should be used for both sections (under a common command) and, to facilitate the survey, light cars (in what proportion he does not say) should be provided for the officers of the section. He, very properly, condemns the common practice of referring to these questions as a species of " black magic " and maintains that they are exceedingly practical and usable methods which gain in importance as the supply of ammunition falls off. The deduction is that, valuable as they were in stationary warfare, they will be of increasing importance in mobile operations. Like other gunners, he condemns reliance on field survey units and would set them free for triangulation and mapping. Meteorological personnel are included in the artillery survey units. The ideal is that of a divisional artillery survey unit, directly under the orders of C.R.A., and, to gain this ideal, the observation of the individual battery must suffer. The unit should consist of aeroplane and balloon observers, survey or trig. section, location section (flash and sound) and meteorological section. The social standing of the survey unit is of importance and so it is recommended that staff employ, high command, and success generally, should be conditional on a well-reported-on year in the section.

The first number of a series of articles by Ludwig Pengoo on the operations at the Col di Lama in 1915–1916 does little more than describe the topography. A capital map is provided on which the bastion character of the Col di Lama is clearly brought out. Both Austrian and Italian communications were under close artillery fire, possible only by night. Two forts, or rather blockhouses, armed with machine-guns and old patterns of field-guns and howitzers, existed in the Col di Lama sector and were garrisoned by the Austrians in 1914. War with Italy had, of course, been thought possible, but had not been studied in connection with a simultaneous Russian and Balkan War. The disappearance of the Italians from the Tirol in August, 1914, and the warning sent to English folk in Cortina by the intermediary of an Italian courier, indicated the probable trend of affairs to the Austrian outposts and the sector was quietly but continuously strengthened. Old men and women began the construction of strong points under sapper supervision. Late in the autumn two labour companies were sent up. Guns were taken out of the forts and placed in the open. The Italians kept a close watch on all these preparations.

There is a highly technical but apparently valuable article on aerial tramways, and two others of minor interest on the Psychology of Discipline and an Anti-aircraft Defence.

H.St.J.L.W.

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HEERESTECHNIK.

(July, August and September Nos.)

CAPT. JUSTROW'S articles on the theoretical conditions affecting the life of barrels are continued through these numbers. His aim is to reconcile theory and practice; to find out exactly what the wear and tear is due to; and to express the various factors in formulæ which will correspond to practical experience. In the past much more discussion has been published dealing with the trajectory than with the conditions which obtain within the gun. In the September number he begins to sum up on the "life" of the barrel. Each article is crammed with equations, however, and no summary review can deal adequately with his matter.

Continuing the account of the attack on Nowo Georgiewsk, General von Schwarte begins by stating that the infantry advance on the night 14–15th August was soon brought to a standstill by Russian artillery and machine-gun fire. On the 15th the bombardment was renewed. The heavy howitzers failed to secure the actual effect, which had been hoped for, on the forts; but the moral effect was important and the Russian artillery was silenced during the afternoon. The infantry pushed forward, and opposite Fort XVA (reckoned to be the most formidable of all) they had reached the edge of the wire entanglement before they were stopped. On the 16th, a foggy morning, the bombardment was taken up again at 9 a.m. and an hour afterwards attempts were made to storm forts XVA and XVB. The attempts were premature, but a lodgment was made in a subsidiary earthwork to the south of XVB. The bombardment had to be reopened and, though directed by artillery officers from the front line, occasioned serious casualties amongst the leading infantry. Two hours later XVB was captured, and held against counter-attacks from XVA and from the thick woods in rear. In the evening XVA fell in its turn. Meanwhile Russian troops were massing in the woods behind for counter-attack. It was reported afterwards by Russian prisoners that 11 battalions were sent forward for this attack, but the larger number never arrived, which may have been due to the fire concentrated on the woods by the German heavies. The attack on XVIA and XVIB (the extreme left on the bank of the Narew) fared worse. The artillery devoted to the purpose was too weak. On the 16th the attacking infantry were brought to a standstill some way from the wire. On the 17th renewed attempts brought them to the forts but could not affect a lodgment, in spite of reinforcements drawn from the front opposite XVA and XVB. But on the night of the 17th in pouring rain the Russians acknowledged defeat and retired, leaving XIV (on the extreme right and not, so far, attacked) empty, and clearing out from the dense woods which run parallel to, and behind, the forts. A general advance to the Wkra encountered small opposition, but a crossing was impossible until Fort III had been bombarded. Meanwhile, Russians were seen digging in on the front Fort XII–Fort II–Fort III and were immediately engaged by field-guns from the south edge of the woods. An attack south of the Narew against an outlying earthwork had, meanwhile, failed, but had had considerable influence on the defence. On the 19th

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all guns were concentrated on II and III and on an intermediate horn-work. In the afternoon a general advance began and by six o'clock had broken the last resistance and captured the whole northern sector. In the course of the evening an unconditional surrender was signed by the Russian Commander. No particular technical lesson is to be drawn from these operations, but they exemplify what can be done with comparatively inferior forces against a supine and demoralized antagonist.

In the *R.E. Journal*, September, we left a German field survey company just as it arrived on the Salonika front. The maps were found very bad; and the Austrian 1/200,000 (the best of a bad lot) showed errors of seven kilometres or so. A printing press was secured after long official wrangles and the new survey begun with the Zeiss photogrammetric camera and with a "Mester" panorama camera (similar, it is presumed, to that used recently in Alaska). Captured maps (presumably British or French) formed the basis for a 1/25,000 series along the front and the country was found exceptionally suitable to stereophotogrammetry.

Capt. Fries describes a commercial "large surface" lorry, or combination, which consists of a 40–45 h.p. 4-ton lorry taking a 10-metre-long trailer. The trailer fits on behind in such fashion as to put about half its weight on the rear axle of the lorry. The combination is easy to turn, and the following advantages are claimed for it:—

1. Weight carried, 8 to 10 tons.
2. The surface is so large that very bulky goods can be carried (or 80 men).
3. The heavy weight on the driving wheels (rear axle of lorry) grips a slippery road.
4. The lorry can be used separately, by detaching trailer.
5. Economy of personnel.
6. The floor of the trailer can be lowered for loading.
7. The length of a column could be lessened by 60 per cent.
8. The greater weight on the axle and slower speed spare roads.
9. Smaller carriage weight than a number of independent lorries.
10. Economy of petrol.

There is an interesting account of the map policy which follows on the change in German survey organization.

All surveys are now in civil hands and a sub-department of the Home Office ("Reichsministerium des Innern") is entrusted with the task of laying down, and presumably enforcing, common policy upon all the individual states. There is a council of 46 which reports to the Home Office and which includes representatives of Army, Navy, transportation and of the various State Surveys. The programme they have decided on will prove of considerable national value. They have decided, unanimously apparently, to introduce a general system of reference analogous to our military grid on all maps. It is a matter of wonder that other nations do not do the same. After all, the military grid was introduced in order to facilitate administration, and to make the way plain to all. It offers the same advantages in peace as it does in war. The 1/50,000 is to be pushed on with when funds permit, a 1/5,000 cadastral is to be made universal, and, for the benefit of topo-

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graphical and cadastral mapping. Gauss conformal co-ordinates are to be based on a new, 3 degree, meridional strip, an arrangement which will prove a wonderful simplification. These changes are all in the direction of facilitating home defence and it is strange to see them assented to by a body of men which includes a service representation of about 4 per cent.

The ninth volume of Schwarte's history of the 1914–18 war deals with the organization of the "Versorgung" of the German Army. Here we have an expression rather hard to translate, and I am afraid we should generally use that abominable term "ancillary services." Medical and Veterinary matters, clothing, equipment, auxiliary water transport, postal and telegraphic services, and supply generally are included. A short notice of its appearance is given in the July number.

A continuation of the article on railways during the French offensive on the Aisne (1917) deals with the metre-gauge Montcornet–Rethel line. Its importance during the battle is illustrated by the fact that as many as 47 supply trains (28 of them with ammunition) ran in a day and the average was not far below this figure. Diagrams of the stations at which the meter-gauge trains were loaded up are given. Much of the line was under long-range fire and on one occasion the Laon station was out of action for 12 hours. The author concludes with the statement that a well-organized railway system is indispensable to a successful defence.

Anti-Aircraft Defence.—This article deals with the defence of national centres and not with that of an army in the field.

It is divided into:—

(*a*) Measures which are purely military—such as the organization of scout and fighting squadrons, anti-aircraft guns and machine-guns, searchlights, balloon and "sausage" screens, etc.

(*b*) Measures of co-operation between civil and military authorities such as the organization of a good system of warning, the camouflage of important centres, of the approaches to them, instructions for the behaviour of civilians during an attack, etc.

As regards military measures, the strength and organization of air-defence units is discussed generally in the spirit of placing them so as to cover as many points as possible, whilst anti-aircraft guns must be more or less stationary. Scouts must go for bombing planes and on no account for their escort. Anti-aircraft guns have to think of three classes of target—bombing planes, fighting escort and those whose job it is to go for anti-aircraft batteries with machine-gun and small bomb. Anti-aircraft batteries are therefore of four varieties:—

(*a*) Heavy and high velocity—height of trajectory at least 7,500 m.
(*b*) Medium calibre—height of trajectory 5,500 m., 20 rounds a minute.
(*c*) Small calibre automatic 3 to 3·7 c.m.—height of trajectory 2,200 m., 150 rounds a minute.
(*d*) Machine gun—heavy and light.

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The anti-gun aeroplanes may succeed in coming down low enough to knock out heavy and medium anti-aircraft batteries unless the latter are protected by machine-guns. The day bomber will be smaller than the night bomber and will be at a height of some 6,000 m., flying at 200 km. an hour, but will hardly carry bombs heavier than 200 kg. Night bombers are bigger, slower and carry much heavier bombs. But it is probable that day bombing will be thought more paying than night bombing—at any rate, at the start of a war. There will be two or three medium-calibre guns for each heavy. Both heavy and medium will be stationary, but the small-calibre will be mounted on lorries. Six *Tables*, which follow, give the radius of full and of medium effects at various heights for heavy, medium, and small-calibre guns, for heavy and light machine-guns, and for searchlights.

Major Klingbeil, in the September number, starts an article on rivers in battle. The increase both in the weight and size of military vehicles (tanks, etc.) and in the range and precision of heavy artillery have added much difficulty to the question. In fact, the crossing of a river under effective heavy artillery fire can hardly succeed by day, or at any rate a complete bridge can hardly be constructed, by day. Probably the first troops must be rafted over. In the first place all preparations must be camouflaged to escape air observation. Rafts will be prepared away from (probably up-stream from) the scene of action, and more men and stores, and better river-reconnaissance than in former times, will be necessary. Weight to be carried will reach at least 12 tons. German pontoons are of war period pattern and the "Ganz" pontoon will take 8 tons. Baulks and road-bearers must be strengthened and experiments in coupling must be tried. The manual which deals with the subject says much about the collection of intelligence under the headings of reports from air-observers, air-photographs, river or canal plans, charts or sections to be found in water transport offices, etc. Emphasis is laid on the breadth of front—one bridge is but a hostage to fortune—and particularly so with the advanced guard.

An interesting and very technical summary of the influence of wind and temperature on the movement of sound waves in the atmosphere began in July and is still unfinished. It is a valuable, if not an original, contribution to the subject and will be reviewed as a whole.

An article on Geology in the world war, which appears in the August number, is a translation of one published in Spanish on the centenary of the university of Buenos Aires. It was, however, prepared by the German scientific society of that town. The first official German geological staff was employed in Flanders in 1915. The work lay mostly in planning and supervising the construction of dug-outs and in advising mining engineers. Gradually they were found a place in every theatre of war, mostly either to find, or to get rid of, water, but also to assist in securing road metal and, indeed, in many ways to be the handmaid of engineering. The total staff to be employed was 250 and a headquarters of 40 in Berlin, under the direction of the survey, provided maps and stores and formed a staff of lecturers. Reference is made to a "Geological Atlas of Flanders" of which over 5,000 copies are said to have been in stock at the end of the war. Wytschaete and

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Professor David are quoted as having given the Germans a costly object lesson. The German engineer seems to have been more dependent on professional advice on this matter than we were. Perhaps because he was a pioneer.

H.St.J.L.W.

VOINA I MIR.

THE fourth number of this Magazine was reviewed in the March number of the *R.E. Journal*; the sixth number maintains the same high standard as its predecessors. It is interesting to note that the old Russian orthography has been preserved.

"The Problem of the Mechanical Conduct of War" by Captain Ritter of the German General Staff is a transcript of Colonel Fuller's article on the subject in the second number of the third volume of the *Army Quarterly* and ends up with a criticism of Colonel Fuller's remarks so far as the use of tanks in a big war is concerned. Whilst acknowledging the general interest and value of Colonel Fuller's article, he disagrees profoundly with many of his assumptions and deductions. For instance, Col. Fuller assumes that an army, otherwise of the modern pattern, would take the field along with mechanical weapons of a new and advanced type, which would, in the author's opinion, be as illogical as if in the late war men armed with pikes had been accompanied by automatic guns, fire-sprinklers and mine throwers.

Colonel Fuller assumes that the war of the future will begin with the collision of squadrons of tanks acting in the same way that cavalry used to. He does not admit the possibility of other branches of the service taking part in these preliminary encounters, infantry and artillery merely acting as interested spectators. He considers that all advance in the construction of armaments will be confined to tanks, and that no improvement will be made in other weapons. The author holds that the experience of the last war is all against this; though on the first appearance of tanks the Germans were helpless, in 1918 they possessed a very formidable anti-tank gun which would doubtless have been perfected if the war had lasted longer. Why should not an anti-tank gun be invented capable of being carried by a single infantry man? Colonel Fuller supposes that the qualities conferred by strong armour and great swiftness can be combined in a tank, though it is well known from the analogy of destroyers that they are incompatible. He discusses the decisive battle between two armies and apparently assumes that tanks will be distributed along the whole front, like skirmishers in a firing line. At Cambrai on November 20th, 1917, the English had 36 tanks distributed over a front of 1,200 metres; on the system enunciated by Colonel Fuller no less than 100 tanks would be required for a frontage of one kilometre; hence, for a battle on the scale of the Marne, about 25,000 tanks would be employed, an obviously impossible number. Colonel Fuller appears to underrate the difficulties to the progress of tanks caused by rivers and forests. He does not do justice to the power of infantry and artillery in dealing with tanks, forgetting that in the fighting in Flanders between October 14th and 19th, 1918, they accounted for nearly 50 per cent. of the tanks in action.

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Infantry will always be the " Queen of the Battlefield " and though its action will, in future wars, be supplemented by some form of light armoured machine-gun, a miniature tank, the successful issue of all fighting at close quarters will ever rest with the infantry and not with a machine.

As regards cavalry, the author agrees with Colonel Fuller that, generally speaking, cavalry attacks are now a thing of the past, with the exception of minor actions between cavalry patrols. Assuming the possibility of constructing the tank scouts envisaged by Colonel Fuller, as a substitute for cavalry, possessing high speed and consequently weak armouring, they would be extremely vulnerable to infantry armed with an anti-tank weapon and would therefore be unsuitable for action in the neighbourhood of large hostile columns. In future wars there will be separate regions of reconnaissance. The areas in which columns are marching will be dealt with by aircraft; cavalry will reconnoitre the no-man's land between the two armies, where detailed examination of the ground is required and where opposition would usually be met with from the enemy cavalry or from hostile inhabitants; but in the case of serious opposition, such as that afforded by an advance guard of a column or cavalry supported by guns, there would be a distinct opening for the use of swift lightly-armoured machines, taking the place of the " striking battalions " of a cavalry division or of a single reconnoitring squadron, but not of a single cavalry patrol as Colonel Fuller suggests.

An article entitled " The Control of Masses in War " by S. Dobrodsky discusses the difficulties met with by commanders who had, of necessity, no experience of the control of the vast multitudes employed on the various fronts in the Great War. In 1914, 2,000,000 Germans deployed against 2,000,000 French and English, and 3,000,000 Russians against 1,800,000 Austrians and Germans, whereas in 1812 Napoleon led 462,000 men across the Niemen; at Leipzig in 1813 the allies numbered 772,000 men and in 1870 the Germans at the end of the first month of war numbered 484,000.

As an example of difficulty of control the author cites the failure of General von Kluck to carry out the orders issued by G.H.Q. at 21 hours on September 4th, and received by him on the morning of September 5th, he being ignorant of the general situation on the whole front and thinking that G.H.Q. was alike ignorant of the frontage of his army which had already crossed the Marne. The author discusses at length the results of this want of mutual understanding. The German leadership in 1914 was based on the same principles as in 1870. A plan had been worked out and elaborated in peace time and had to be carried to a successful issue. When once the working of the plan had been started its fulfilment was supposed to follow automatically. Hence, when the German High Command found that the execution of their plan was being frustrated by an enterprising and well-found enemy, it preferred to withdraw its troops behind trenches to risking the improvisation of a new one.

In the second part of the article the author describes how, at the beginning of the war, the French were similarly handicapped by a lack

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of experience, but by degrees method in the control of masses was forged out. He traces at length the steps by which success was eventually obtained in 1918.

In the third part the author discusses the questions of reserves, of adapting plans to meet unexpected situations, of manœuvring troops rapidly by means of trains, lorries, taxicabs, etc., and of the necessity of close contact between a C.-in-C. and his troops. The article ends with a eulogy of Marshal Foch.

An article by Colonel Kolossovsky, of the General Staff, on coast defence, includes a transcript of an article by Lieut.-Colonel de Watteville in the *R.A. Journal*, and a description with illustrations of the guns used by the United States for coast defence; also a short account of the organization of coast defence in France for which the Navy has been responsible since December, 1917.

"Ideas of Officers of the American Army on Infantry Tactics," is a discussion of two articles on infantry tactics recently published in American journals and is preceded by a lucid dissertation on the subject by the editor of *Voina i Mir*, General Professor A. Kelchevsky. He considers that the French have been unduly influenced by four years of position warfare in arriving at certain conclusions regarding infantry formations and armament. He sums up the question of attack *versus* defence. Since the appearance of fire-arms the defender has always had an inherent advantage over the attacker, owing to the greater facilities he enjoyed for the efficient use of his weapon. The problem of the attack has always been to combine forward movement with efficient fire effect. The first method adopted in solving the problem was the use by the attack of masses of artillery, as practised by the Germans with success in 1870–71. The efficacy of this method was neutralized twenty years later by the introduction of the magazine rifle and quick-firing artillery, leading, in turn, to the use of concentrated artillery fire by the attack. The Russo-Japanese war confirmed previous experience whilst it showed that the employment of machine-guns, though of great advantage to the attack, was even more advantageous to the defence. The "radical question" of the attack—forward movement without the slackening of fire—was still unsolved. The Germans, ever trying for a solution, had recourse to the heavy artillery for field warfare, and their successes at the beginning of the Great War must be largely attributed to the splendid work of their heavy guns. Position warfare with its labyrinths of trenches, led to the vast increase in numbers and range, of heavy ordnance used by the attack for protracted preparation at long range, a method which, to a great extent, defeated its own end by abolishing the element of surprise. Hence the adoption of another method, in which a larger number of guns was employed for a short period to crush the defender on the portions of the front destined for attack. The reply of the defence was the position in depth, which tended to deceive the attack as regards the main position of resistance, facilitated counter-attack on his flank and drew him beyond the supporting range of his artillery. The problem of the attack still remained unsolved, but human ingenuity rose to the occasion. In 1916 tanks made their appearance; the problem was nearly solved,

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but not quite, for the artillery of the defence, profiting by its range and comparative invulnerability, continued to inflict losses both on infantry and tanks. Tanks could not work alone, but had to be accompanied by infantry to occupy and make good the ground passed over. The dispersal of the defending infantry in depth in small centres of resistance necessitated the dispersal of the attacking infantry in groups. Arguing from this special form of warfare, a peculiar outcome of the war of position, the French have adopted formations and armaments suitable for it, but ill adapted to open warfare. The true solution of the problem lies in the use of tanks and caterpillar artillery. The whole of the divisional light artillery, which should be self-propelling and provided with armour for the engine as well as a shield, having co-operated with the other forms of artillery in the preparation for the attack, must advance with the infantry on a level with the battalion reserves and take part not only in the initial barrage but continue its fire in the form of a moving barrage. The artillery must keep close visual connection with the infantry and help it to thrust its way in, overcoming by its fire everything which the tanks have failed to deal with. By such methods, after a century of efforts will the problem of the attack. advance without slackening of fire, be solved.

An article on the effect of heavy artillery by Colonel Bauer, of the German General Staff, has some good photographs showing the result of heavy shell-fire in armoured turrets and brickwork at Liége, but does not appear to contain any very striking conclusions.

A.H.B.

THE MILITARY ENGINEER.

September–October.

The Military Map of the Future.—The author describes the production of the "pictorial relief map" which is obtained by super-imposing on a topographical contour map a high-light photograph of an equally accurate relief model of the same area. Being produced by mechanical means from an accurate model, the map presents a truer interpretation of the hill features than has hitherto been possible with shaded and tinted maps dependent on the skill of the artist. The value of the relief model map is unquestioned; production in sufficient quantities has always been the difficulty. The pictorial relief map appears to provide an efficient substitute.

The Coast Artillery and the Engineers.—Soon after America's entry into the war, the Coast Artillery Corps sent heavy artillery personnel to France. The material was furnished by the Allies, and simultaneously the United States undertook the manufacture of its own heavy guns. The Armistice, however, intervened before quantity production was attained, but America now possesses a good supply of railway and tractor-drawn artillery.

The war demonstrated the value of mobility, dispersion, and concealment, and mobile artillery will play an important part in future coast-defence policy. It is considered that only the heaviest guns should be provided with permanent emplacements. The co-operation of Engineers

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will be required in a still wider field for the design, construction, repair and modification of emplacements and fire control stations, etc., for roads and bridges for heavy tractor material, for the collection of railway data, and the construction of additional sidings.

An interesting system of fire control, based on subaqueous sound-ranging is being developed. This serves two purposes—to locate a hostile ship by its under-water noises and to record the pitch of a projectile by its impact on the water. Work is still in the experimental stage, but is sufficiently advanced to be used in emergency.

R.I.M.

SAPER I INZYNIER WOJSKOWY.

2nd Year No. 2.

On the occasion of the opening of the new Engineer Officers' School in Warsaw, the Polish *Sapper and Military Engineer* devotes most of its space in this number to the education of Engineer Officers, articles appearing on the methods observed in France, Austria and Petrograd past and present. An introductory paper, by Engineer Colonel Ozynski, describes the organization which is being adopted for the new School, mainly based upon that of their victorious Allies, the French. The intention is to give the students the fullest possible technical education both in engineering and military science, while sports and physical training are not neglected. The course will last three full years and in each summer the students will pass 10 weeks in training camps, and be given 5 weeks' leave at their homes. Education, clothing and food will be free of cost. The annual batches will each consist of 100 students, the whole being organized into a Battalion of three Companies. After the completion of the second year's course and passing the necessary examinations, the students for their third year will be commissioned as 2nd Lieutenants. The first Commandant of the School is Engineer Colonel Haller, who obtained his education in the Mikolevski Engineer Academy at Petrograd, and he will be assisted by a Director of Studies, a Commander of the School Battalion and a School Quartermaster. There is also a School Council, with the Director of Studies as its Chairman, which advises the Commandant on all questions concerning the appointment of the Professors and instructional staff, and the Commandant in his turn makes his recommendations to the Staff Department V (Engineers and Sappers), which, in consultation with Staff Department VI (Military Education) makes the appointments. The School is accommodated in Warsaw, in the buildings of the former Chief Artillery and Engineer School, which have been remodelled and considerably added to for this purpose, from the designs of the well-known architect Cz. Domanievski, Professor of the Warsaw Polytechnic.

F.E.G.S.

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CORRESPONDENCE.

THE 21ST COMPANY, R.E., AT THE BATTLE OF BETWA.

To the Secretary, Institution of R.E.

DEAR SECRETARY,

I have read with great interest your excellent Memoir of Sir Bevan Edwards in the *R.E. Journal.*

At page 136 you quote Sir Hugh Rose's dispatch. This dispatch was communicated to Chatham by Sir John Burgoyne. I was at Chatham at the time and heard it read out on parade.

My recollection is that Sir John Burgoyne's instruction was that the dispatch should be *read out on parade at all stations where the R.E. were quartered.* Probably you would verify this from the Chatham records.

My object in writing is that I think you might find it suitable to quote in the next issue the instruction I have underlined. The instruction clearly added to the honour which Sir John Burgoyne desired to confer on Edwards.

We all felt very proud indeed of Edwards' feat, and in conversation I have often and often referred to it with pride.

Observe that the enemy were in overpowering numbers, and that the 21st Company absolutely put them to flight.

Yours sincerely,

W. SALMOND.

The Secretary regrets that he has been unable to obtain any confirmation of Sir William Salmond's interesting reminiscence, as the Records of the S.M.E. do not go back to 1858. *Possibly some one of our readers may remember the incident?*

ERRATUM.

In September *R.E. Journal*, page 501, the Christian names of Lieut. Dickson should read James Whyte Melville.

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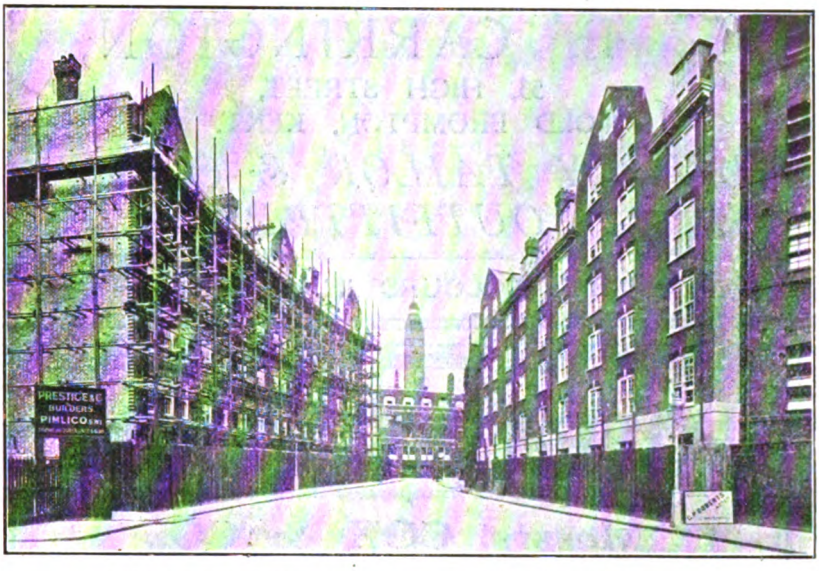

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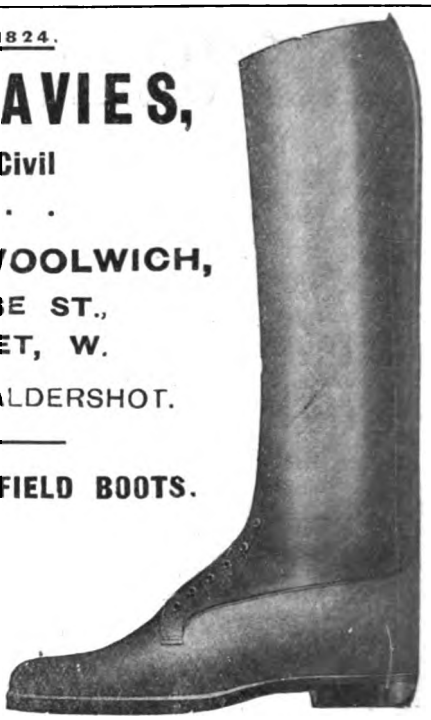

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